

CONTROLLING INJECTION OF FLUIDS INTO WELLS

This invention relates to apparatus for controlling the injection, into a well tubing string, of fluid such as gas for gas lift operations or liquids containing treatment chemicals; and more particularly to side pocket mandrels and flow control devices in the side pocket receptacles of such mandrels.

Side pocket mandrels have been used for many years for different applications involving the flow of fluids from the exterior of a tubing string into the interior thereof. Such applications include the practice of gas lift techniques for recovery of oil from oil wells, and the injection of liquids which may include treatment chemicals for different treatment purposes within the well. Davis et al U.S. Patent 4,066,128, issued January 3, 1978, is concerned with a side pocket mandrel including a flow control device in the side pocket receptacle thereof for controlling the injection of gas into the tubing string for a gas lift operation. The flow control device of this Davis patent includes a sliding sleeve valve which controls the port opening into the side pocket receptacle from the exterior of the mandrel, and which is shiftable between a port-closing and a port-opening position. This sliding sleeve valve is operated automatically by a flow control valve which is inserted selectively into the side pocket receptacle of the mandrel. When the control valve is placed therein, the sleeve valve is moved automatically to the port-opening position; and when the control valve is removed from the receptacle, the sliding sleeve valve is moved automatically to the port-closing position.

A disadvantage of the flow control device of the Davis patent is that the sliding sleeve valve is not removable from the side pocket receptacle. Accordingly, with this design, should the sliding sleeve become

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defective and require servicing or replacement, it will be necessary to shut down the well and withdraw from the well the side pocket mandrel carrying that sliding sleeve valve and of course all of the associated production
5 tubing string. This is obviously a time consuming and expensive procedure, and a much preferred form of flow control device would include a sliding sleeve valve which could be removed from the side pocket receptacle either for servicing or replacement.

10 According to the present invention there is provided a flow control valve for use in a well device for controlling flow between the exterior and interior of a well flow conductor; said well device including a side pocket mandrel having an elongated receptacle and an
15 external side port opening to said receptacle, and a sliding sleeve valve disposed for movement in said receptacle between an upper closed position and lower open position relative to said side port;

said flow control valve comprising an elongated
20 body, configured to be received within said receptacle, having latching means for latching engagement with said sleeve valve; said control valve latching means comprising axially extending collet fingers with inwardly projecting distal lugs, for coaction with latching means
25 of said sleeve valve.

Reference is now made to the accompanying drawings, in which:-

Figures 1A, 1B and 1C, taken together, constitute a longitudinal sectional view of a side pocket mandrel and
30 the sliding sleeve valve of a flow control device according to the invention;

Figures 2 and 3 are transverse sectional views taken along the lines 2-2 and 3-3, respectively, of Figure 1;

Figures 4A and 4B, taken together, constitute a
35 fragmentary longitudinal sectional view of a side pocket

mandrel and flow control device according to the invention;

Figure 5 is a transverse sectional view taken along the line 5-5 of Figure 4A;

5 Figure 6 is a fragmentary longitudinal sectional view of a side pocket mandrel and flow control device according to the invention, showing the flow control device, in a different operative condition;

10 Figure 7 is a fragmentary longitudinal sectional view of the side pocket mandrel and flow control device, showing the flow control device in still another operative condition;

Figure 8 is a fragmentary longitudinal sectional view of a pulling tool for a sliding sleeve valve shown 15 in one operative position in a side pocket mandrel; and

Figure 9 is a fragmentary longitudinal sectional view of the assembly of Figure 8 shown in another operative condition.

The drawings illustrate a side pocket mandrel 10 for 20 connection into a well flow conductor in the form of a tubing string consisting of sections or joints of tubing; the side pocket mandrel being connected between adjacent joints and forming part of the string. The side pocket mandrel is an elongated generally tubular member having a 25 projecting belly portion 11 at one side which forms the side pocket. The side pocket mandrel has a main bore 12 axially aligned with threaded pins at the opposite ends of the mandrel, so that the main bore will be axially aligned with the bore of the tubing string. A smaller 30 generally parallel bore 13 is formed in the side pocket and defines a receptacle for the flow control assembly to be described.

The side pocket is opened to the main bore 12 for a substantial length above the receptacle 13 to enable the 35 lateral placing of a tool in generally axial alignment

with the receptacle to be then moved downwardly into the receptacle; and guide cams 14 are provided to assist in guiding a tool from the upper pocket portion into the receptacle. At the upper end of the mandrel 10, an orienting cam 15 is provided in association with the main bore 12. This orienting cam is provided to rotationally orient a tool which is lowered through the main bore and carries a tool to be placed in the side pocket receptacle, the tool being then oriented to enable the lateral placement of the tool into the side pocket.

A side inlet port 21 communicates the receptacle with the exterior of the side pocket 11. In the illustrated form of side pocket mandrel, a discharge passage 16 is formed at the lower end of the pocket in generally axial alignment with the receptacle 13; and this discharge passage terminates in a threaded box to enable connection of a side tube or string 25 for conducting fluid, such as chemical treatment fluid, to a lower point in the well. In another type of side pocket mandrel, a discharge passage might communicate the lower end of the receptacle with the main bore to provide for the injection of fluid from the receptacle into the main bore. In either case, the flow of fluid from the receptacle is under the control of a flow control assembly to be now described.

The lower portion of the receptacle 13 is configured for coaction with a sliding sleeve valve 30; and the wall of this lower portion is cylindrical and of generally uniform section to provide seal surfaces for coacting annular seals of the sliding sleeve valve. This lower receptacle portion terminates, at its upper end, in an outwardly bevelled shoulder 17. Intermediate the ends of this lower receptacle portion there are provided latching and relief recesses 18 and 19, respectively; and the receptacle wall portion 20 between these recesses has a

slightly larger diameter than the wall immediately above the upper latching recess 18, the purpose of which will be described subsequently.

5 The upper portion of the receptacle 13, above the shoulder 17, is at least slightly larger in diameter than that of the lower portion; and this upper portion particularly includes an annular latching recess 23 for latching a flow control valve as will be described.

10 The sleeve valve 30 consists of an elongated tubular body provided with a plurality of elongated circumferentially spaced collet fingers 31 intermediate its ends. The inner diameter of the sleeve valve is uniform at both ends, and at the central portion the inner diameter is greater to define a central thin wall section bounded by upper and lower shoulders 32 and 33. 15 The collet fingers 31 are formed by circumferentially spaced slots formed in this thin wall section; and these slots, in addition to forming the collet fingers, also form fluid ports through the wall of the sleeve valve, 20 integral outwardly extending lugs 34 are formed intermediate the ends of respective collet fingers 31, for latching engagement with the latching recess 18.

Two external annular seal members 35 and 36 are provided at the lower end portion of the sleeve valve, 25 below the collet fingers 31; and these seal members are axially spaced for coaction with the inlet port 21 as will be described. An upper annular seal member 37 is provided adjacent to the upper end of the sleeve valve for sealing engagement with the seal surface above the 30 latching recess 18.

An external annular latching groove 38 is provided adjacent to the upper end of the sleeve valve for coaction with the control valve as will be described.

35 The control valve 40 is an elongated assembly consisting of four stacked components, namely: an upper

latch body 41, a latch collet 42, a latch adaptor 43, and an elongated nose 44. The latch body 41 houses the mechanism for latching and unlatching the control valve from the side pocket receptacle 13; the latch collet and latch adaptor provide the mechanism for latching the control valve to the sliding sleeve valve 30; and the nose 44, which is received within the sliding sleeve valve, includes a valve mechanism for controlling fluid flow.

10 The latch mechanism for the control valve 40 is a rotating cam 45 mounted for rotation about an axis perpendicular to the longitudinal axis of the control valve assembly, and which is spring biased for rotation in a clockwise direction (as viewed in the drawings) for
15 coaction with the latching recess 23. A fishing neck 46, mounted on the upper end of the latch body, extends within the latch body and provides a shoulder 47 at its lower end for coaction with a mating shoulder of the rotating cam, to limit rotation of that cam to the
20 position wherein its integral latching lug projects laterally into the latching recess. The biasing spring permits counterlockwise rotation of the cam to permit entry of the control valve assembly into the receptacle. The fishing neck 46 is pinned to the latching body 41 by
25 means of a shear pin 48 to maintain the shoulder 47 in the described interference position. The latching adaptor provides a lower reduced diameter portion, which coincides with the outer diameter of the nose 44, and a larger diameter upper portion thereby defining downward
30 facing annular shoulder 51 for engagement with the upper end of the sleeve valve 30. The latch collet 42 provides downward extending, circumferentially spaced collet fingers 50 which extend below the shoulder 51 of the latch adaptor; and the collect fingers have inwardly
35 integral lugs at their distal ends for coaction with the

sleeve valve latching groove 38 as will be described.

The nose 44 is a hollow member providing a chamber for the control valve mechanism, a lateral inlet port 52 intermediate its ends opening to the chamber, and a
5 discharge port 53 from the chamber at the lower end of the nose. External annular seals 54 are provided adjacent to the upper and lower ends of the nose 44 for sealing engagement with the internal seal surfaces of the sleeve valve above and below the collet fingers 31. An annular
10 valve seat member 55 is provided within the nose chamber between the inlet and outlet ports. A valve closure member 56, for coaction with the valve seat 55, is mounted in a collet sleeve 57 which is in turn mounted for limited upward movement within the nose 44. A
15 bellows 58 is secured in sealing relation between the lower end of the collet sleeve 57 and the nose housing to define a sealed chamber 59 above the collet sleeve to be charged with a charge of gas at a selected pressure. By this means a selected biasing force is provided to
20 maintain the valve closure member 56 seated on the valve seat 55. The bellows sleeve 57 provides a downward facing piston area exposed to the fluid entering the inlet port 52, to effect the lifting of the valve closure member when the pressure of this entering fluid is
25 sufficient.

The several stages of operation of the described well flow control device will now be described. Figures 1A, 1B, 1C, 2 and 3 illustrate the device with the
30 sliding sleeve valve disposed in the closed position, wherein the annular seals 35 and 36 are disposed on opposite sides of the inlet port 21 of the side pocket mandrel. The sliding sleeve valve, then, excludes the fluid surrounding the side pocket mandrel from entering
35 the interior of the mandrel. The sleeve valve is



maintained in this closed position by the latching of the
collet lugs 34 within the latching recess 18. The sleeve
valve will have been placed in this position within the
side pocket receptacle 13 prior to running the side
5 pocket mandrel into the well with the tubing string.
Alternatively, the sleeve valve 30 may have been placed
within the receptacle by a suitable running tool. It
will be seen that, in this closed position of the sleeve
valve, the upper end of the valve, including the latching
10 groove 38, extends above the receptacle shoulder 17.

The control valve 40 is run into the well by means
of a suitable tool which is engaged with the upper end of
the latch body 41, and which coacts with the orienting
cam 15 to place the control valve into the side pocket of
15 the mandrel 10 and to lower the control valve into the
receptacle 13. Figures 4A, 4B and 5 illustrate the
control device where the control valve 40 has been
lowered to the point where it just engages the upper end
of the sleeve valve 30. It will be noted that in a
20 normal condition of the collet fingers 50, the inner
diameters of the latching lugs of the collet fingers is
greater than the outer diameter of the upper end of the
sleeve valve, so that the collet fingers pass over the
sleeve valve for lateral alignment with the latching
25 groove 38. The latch adaptor shoulder 51 is seated
against the upper end of the sleeve valve so that further
downward movement of the control valve will effect
coincident downward movement of the sleeve valve. The
rotating cam 45 has been rotated back by the receptacle
30 wall, and in position to move into the latching recess
23.

With further downward movement of the control valve,
the assembly has been moved downward to the open position
of the sliding sleeve valve which is illustrated in
35 Figure 6. With this further downward movement, the

distal ends of the collet fingers 50 have been cammed inward by the shoulder 17 to engage the collet finger lugs in the latching groove 38 of the sleeve valve; and the two valves are then locked together axially. With the downward force applied by the control valve, the lugs 34 of the sleeve valve collet fingers are cammed inwardly and pass along the wall 20 to move into latching engagement with the lower relief recess 19. This lower relief recess is provided to allow the collet fingers 31 to relax. In this position the rotating cam 45 of the latch body 41 has moved into alignment with the latching recess 23 and snaps into latching engagement to prevent upward movement of the assembled valves until that rotating cam is released. In this open position of the sleeve valve, the annular seal 35 has moved below the side pocket inlet port 21 so that this inlet port is now communicated with the sleeve valve port defined by the slots between the collet fingers 31, and with the inlet port 52 of the control valve. The valve closure member 56 and its associated collet sleeve 57 are now exposed to the pressure of fluid in the well annulus. When that annulus pressure is sufficient, the closure member 56 will open to allow the flow of fluid to the discharge port 53 through the side pocket discharge passage 16 to the side string 25 of this illustrated embodiment.

It will be noted that a relief port 22 in the pocket wall, below the inlet port 21, now communicates the space between the seals 35 and 36 with the exterior of the pocket to relieve trapped pressure.

When it is desired to close the inlet port 21 of this particular side pocket, a suitable pulling tool is run into the well and displaced into the side pocket to engage the fishing neck 46 of the control valve. With subsequent upward movement of the fishing neck 46, the shear release pin 48 will be sheared since the rotating

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cam will not allow upward movement of the latch body 41. With the shearing of the release pin 48, the shoulder 47 of the fishing neck is lifted out of its interference relation with the shoulder of the cam 45, allowing the
5 cam to be rotated further by the spring to release it from the latching recess 23.

Further upward pulling on the fishing neck will raise the control valve 40; and since the lugs of the
10 collet fingers 50 are engaged in the latching groove 38, the sliding sleeve valve 30 will be moved upwardly until the latching lugs 34 engage the latching recess 18. The movement of the lugs 34 is permitted by the fact that the larger diameter of the wall portion 20 permits the passage of the lugs through the allowed deflection of the
15 collet fingers 31 permitted by the control valve nose 44. However, because the receptacle bore 13 above the latching recess 18 is smaller, the allowable inward deflection of the lugs 34 will not allow upward movement beyond the latching recess 18.

20 In this position, illustrated in Figure 7, the upper end of the sleeve valve 30 has now moved beyond the shoulder 17 allowing expansion of the collet fingers 50 to release the control valve from the sleeve valve. Hence further upward movement of the control valve, will
25 separate the control valve from the sleeve valve and allow withdrawal of the control valve from the well. The sleeve valve then remains in the closed condition illustrated in Figure 1C.

Figures 8 and 9 illustrate the structure and
30 operation of a pulling tool 60 suitable for withdrawing the sleeve valve 30 from the mandrel receptacle 13, should that become necessary because of malfunction of the valve or of a need for servicing or replacement. The pulling tool is an elongated assembly consisting of a
35 body 61 and a sleeve 62. The body is threaded at its

upper end for attachment to a suitable running tool 63, shown fragmentarily in the drawing.

The body is provided with an external radial flange 64 adjacent to its upper end; and its lower end is threaded to receive a nose piece 65 which serves to prevent loss of the sleeve 62. Adjacent to its lower end, the body is provided with a conoid cam surface 66, and immediately upward from the conoid cam surface is an annular latching groove 67.

10 The sleeve 62 is mounted for close sliding relation with the body 61, and is provided with an external radial flange at its upper end. The lower end of the sleeve terminates in axially extending circumferentially spaced collet fingers 72; and the distal ends of these fingers
15 are enlarged to provide radially inward extending lugs 73 and radially outward extending lugs 74. In the assembled form for running into the receptacle 13, the sleeve 62 is pinned to the body 61 by means of a shear pin 75. In this pinned position, the inward directed lugs 73 are disposed
20 just below the conoid cam surface 66.

Figure 8 illustrates the condition of this pulling tool when it has been run into the receptacle 13 to the point where the sleeve flange 71 has just engaged the upper end of the sliding sleeve valve 30. It will be
25 seen that the pulling tool assembly is sufficiently long that, in this condition, the outward extending lugs 74 are disposed below the upper internal shoulder 32 of the sleeve valve. It will be seen that the outer diameter of the sleeve lugs 74, in this condition, is just small
30 enough to pass through the smaller diameter bore of the sleeve valve 30.

With further downward movement of the pulling tool 60, the sleeve flange 71 engages the shoulder 17 of the receptacle 13, which prevents further downward movement
35 of the sleeve. With further downward movement of the

body 61 then, the shear pin 75 is sheared and the body is moved downward to engage its flange 64 with the sleeve flange. In this condition the conoid cam 66 of the body has cammed the collet fingers outward; and the inward
5 lugs 73 of the collet fingers then lock in the body latching groove 67. In this locked condition, the outward lugs 74 are positioned in interference relation with the sleeve valve shoulder 32, so that the pulling tool 60 can not now be separated from the sleeve valve
10 30.

With subsequent lifting of the pulling tool body 61, the sleeve is also lifted through the latching of the lugs 73 in the groove 67; and when the outward lugs 74 engage the sleeve valve shoulder 32, the sleeve valve
15 will be lifted out of the receptacle along with the pulling tool. The pulling tool is dimensioned, relative to the sleeve valve collet fingers 31, that the lugs 34 may deflect inward sufficiently to disengage from the latching recess 18 to allow withdrawal of the sleeve
20 valve.

What has been described is a unique well device for the purpose of controlling the flow of injection fluid from the annulus surrounding the production tubing string into that tubing string at one or more points within the
25 well. A principal feature of the invention is the latching mechanism for the sleeve valve which incorporates coaction of the sleeve valve design, the configuration of the receptacle, and the coaction of a portion of the control valve which is selectively joined
30 with the sleeve valve to effect and control the flow of injection fluid. This coacting latching mechanism effects positive latching of the sleeve valve in the closed position, allows ready shifting of the sleeve valve by the control valve to the open position, and upon
35 removal of the control valve effects positive shifting of

the sleeve valve to the closed position and release from the sleeve valve to prevent withdrawal at that point from the receptacle.

Another feature of the invention is that the design
5 of the sleeve valve permits it to be withdrawn readily from the receptacle when replacement or servicing is required. Similarly, the replacement or reconditioned sleeve valve may be readily replaced within the receptacle of the side pocket mandrel.

10 Reference is made to our U.K. Patent Application 8326953 from which the present specification has been divided.

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CLAIMS

1. A flow control valve for use in a well device for controlling flow between the exterior and interior of a well flow conductor; said well device including a side pocket mandrel having an elongated receptacle and an external side port opening to said receptacle, and a sliding sleeve valve disposed for movement in said receptacle between an upper closed position and lower open position relative to said side port;

said flow control valve comprising an elongated body, configured to be received within said receptacle, having latching means for latching engagement with said sleeve valve; said control valve latching means comprising axially extending collet fingers with inwardly projecting distal lugs, for coaction with latching means of said sleeve valve.

2. A flow control valve as set forth in Claim 1

said collect fingers being configured to be urged radially inwardly by a receptacle surface into latching engagement with said sleeve valve latching means when said control valve engages said sleeve valve in said receptacle for downward movement thereof, and to be released from said latching means upon subsequent return movement of said sleeve valve to the engage position.

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