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(54) **TELEMETRIC CHEMICAL INJECTION ASSEMBLY**

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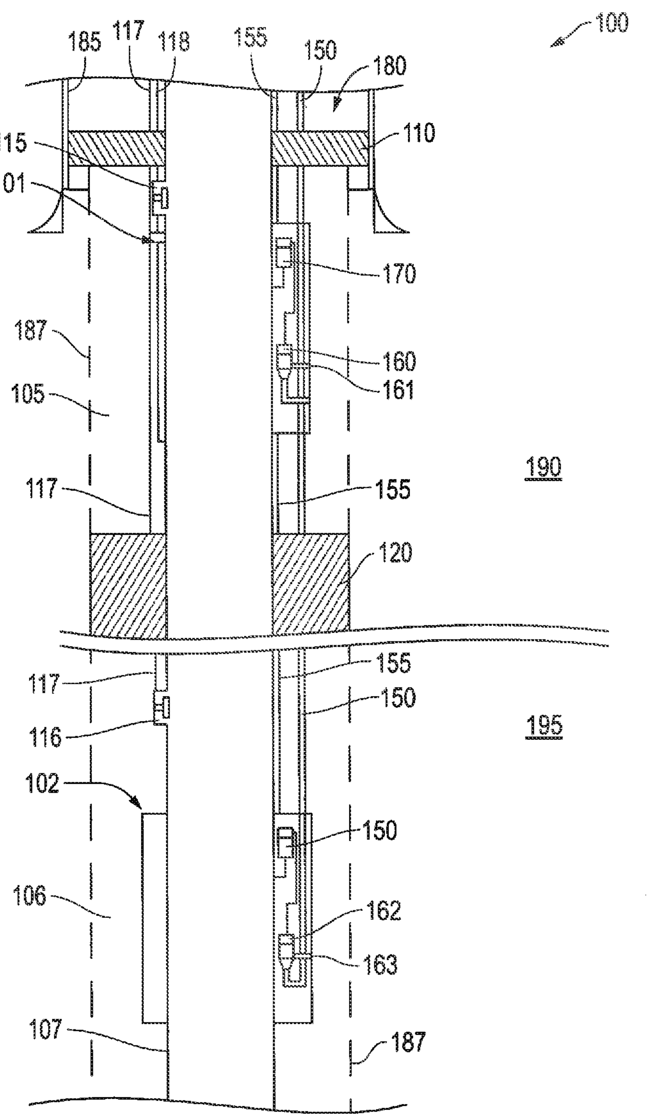
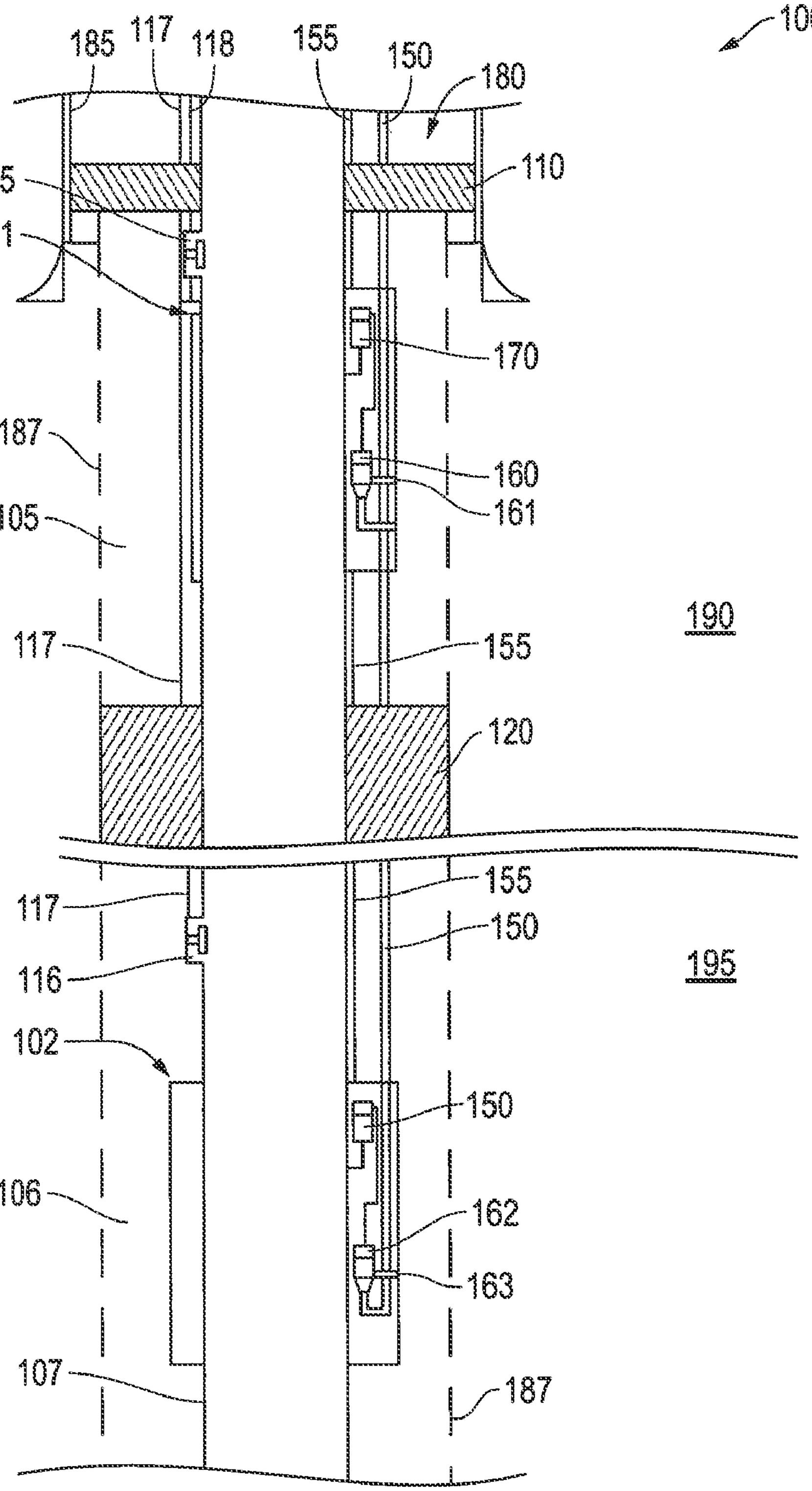
(57) **ABSTRACT**

A chemical injection assembly with telemetric capacity and a single fluid injection line capable of reaching multiple downhole injection points. The assembly may take advantage of downhole power telemetry modules so as to intelligently power and direct actuator valves at any of a number of different injection points. So, for example, the need for cumbersome and expensive usage of different delivery lines dedicated to serve different delivery points with the same fluid may be avoided.




100
185
117
118
155
150
180
115
110
101
170
187
160
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105
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120
117
155
150
116
195
102
150
106
162
163
107
187

FIG. 1

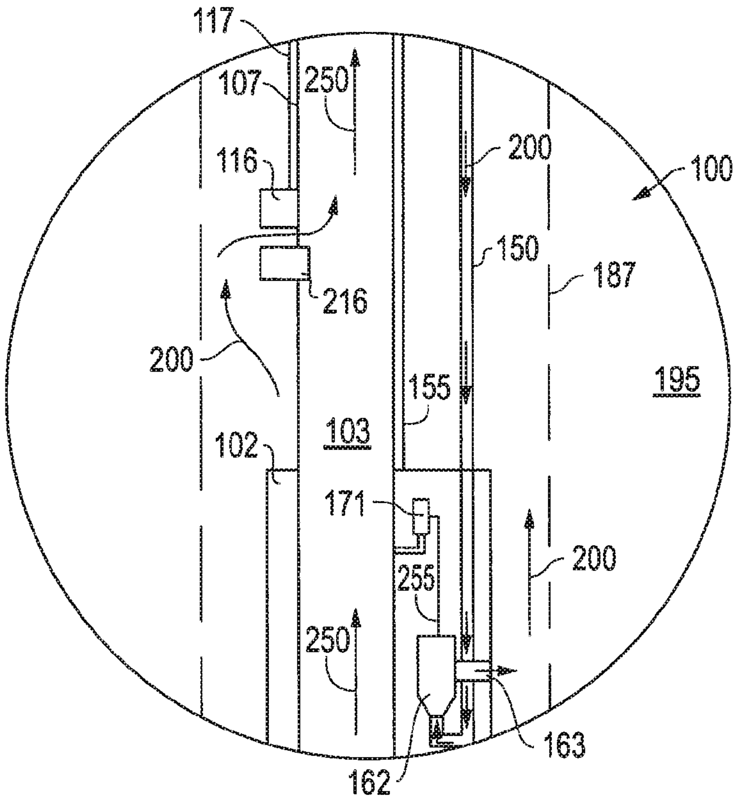
117
107
250
116
200
100
216
150
187
200
195
155
103
102
171
200
255
250
163
162

FIG. 2A

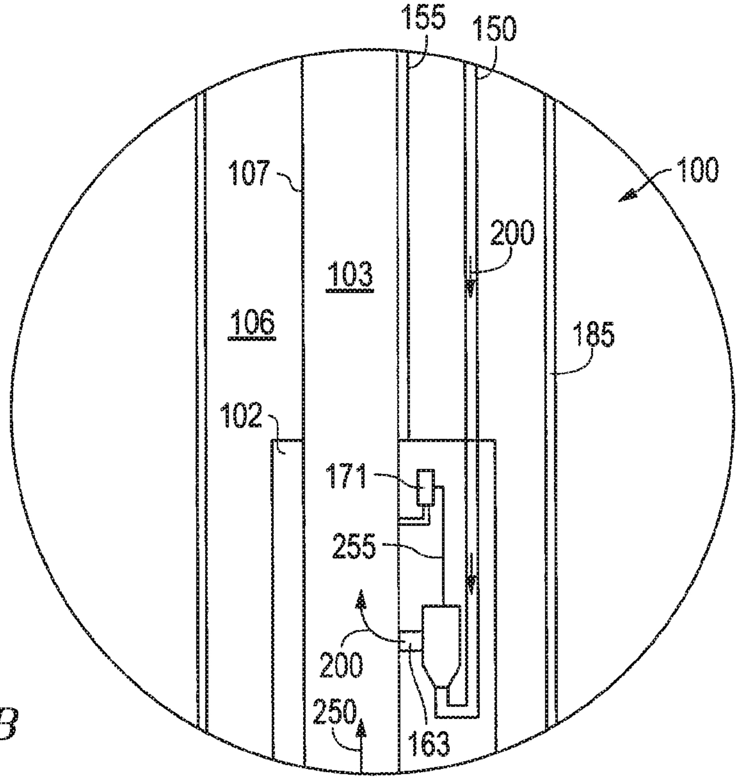
155
150
107
100
200
103
106
185
102
171
255
200
250
163

FIG. 2B

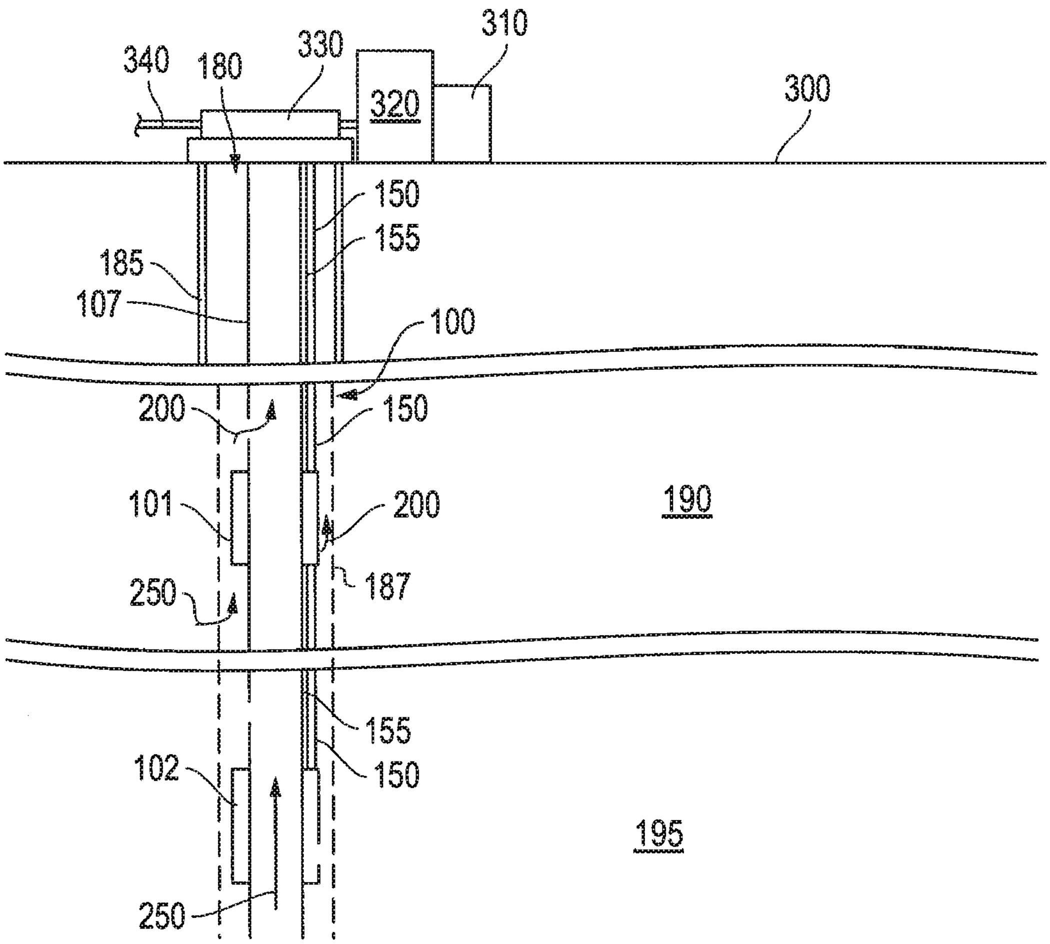
340
180
330
320
310
300
150
155
185
107
100
200
150
101
200
190
250
187
155
102
150
195
250

FIG. 3

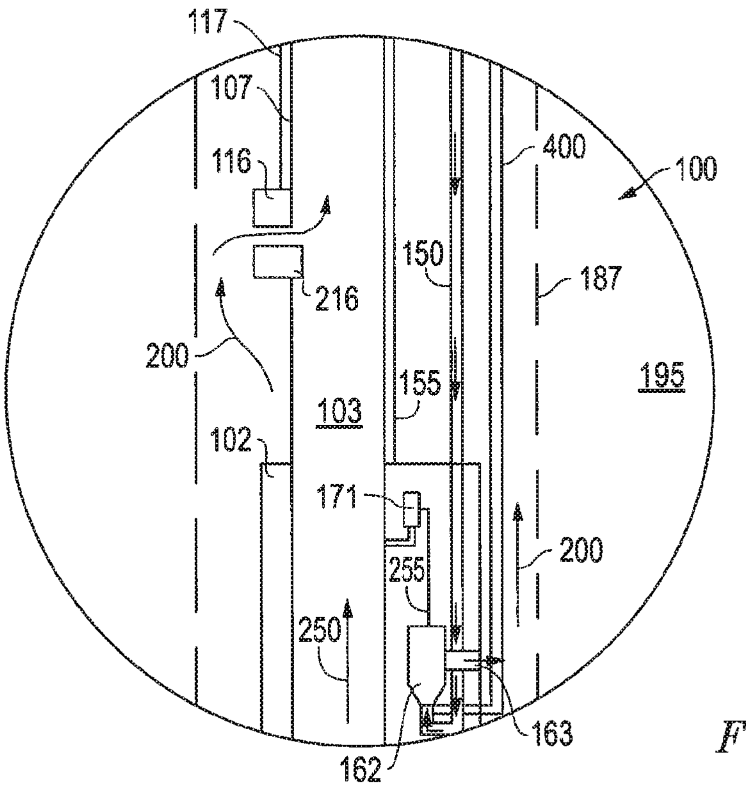
117
107
116
216
200
103
102
150
155
171
255
250
162
163
400
100
187
195
200

FIG. 4A

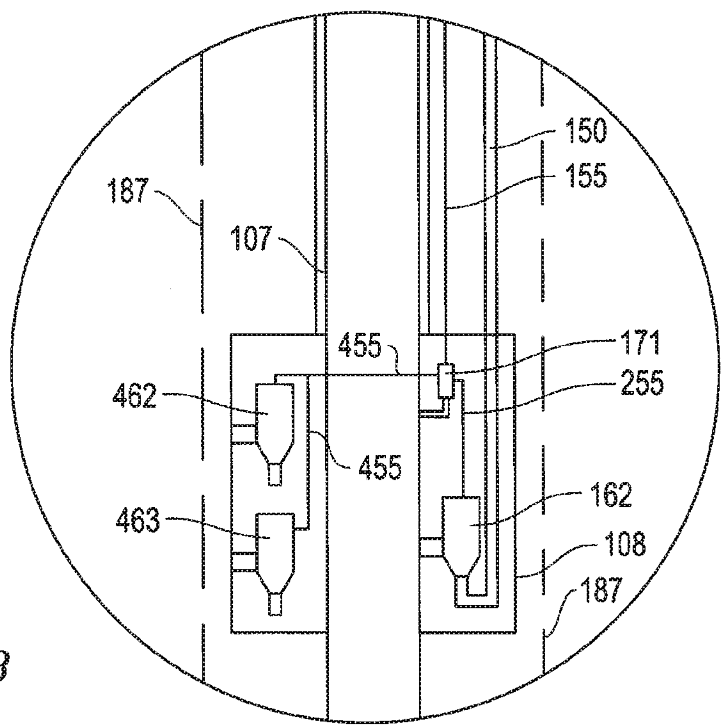
187
107
462
463
455
455
171
255
150
155
162
108
187

FIG. 4B

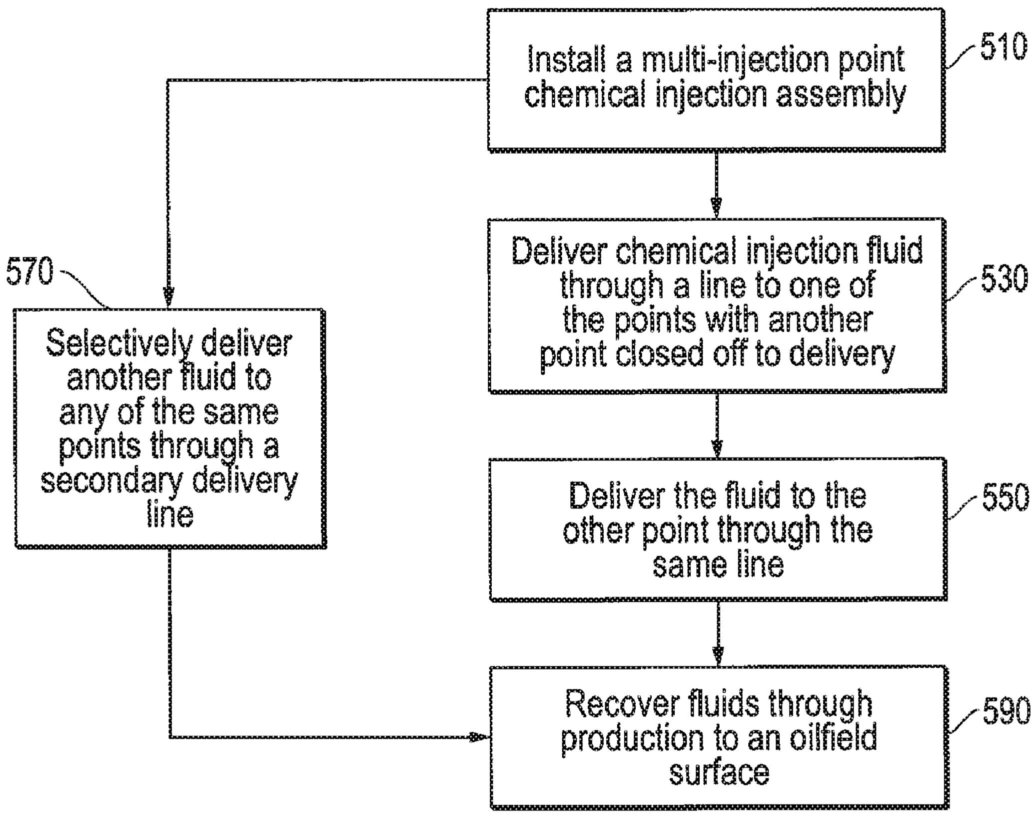
Install a multi-injection point chemical injection assembly
510
Deliver chemical injection fluid through a line to one of the points with another point closed off to delivery
530
Deliver the fluid to the other point through the same line
550
Recover fluids through production to an oilfield surface
590
570
Selectively deliver another fluid to any of the same points through a secondary delivery line

FIG. 5

TELEMETRIC CHEMICAL INJECTION ASSEMBLY

PRIORITY CLAIM/CROSS REFERENCE TO RELATED APPLICATION(S)

[0001] This Patent Document is a Continuation-In-Part claiming priority under 35 U.S.C. §120 to U.S. application Ser. No. 13/364,785, entitled "Chemical Injection Regulation Mechanism", filed Feb. 2, 2012, and which claims priority under 35 U.S.C. §119 to U.S. Provisional App. Ser. No. 61/438,995, filed on Feb. 3, 2011, and entitled, "Chemical Injection U-Tube Prevention System", both of which are incorporated herein by reference in their entireties.

BACKGROUND

[0002] Exploring, drilling and completing hydrocarbon wells are generally complicated, time consuming and ultimately very expensive endeavors. As a result, over the years increased attention has been paid to monitoring and maintaining the health of such wells. Significant premiums are placed on maximizing the total hydrocarbon recovery, recovery rate, and extending the overall life of the well as much as possible. Thus, logging applications for monitoring of well conditions play a significant role in the life of the well. Similarly, significant importance is placed on well intervention applications, such as clean-out techniques which may be utilized to remove debris from the well so as to ensure unobstructed hydrocarbon recovery.

[0003] In addition to interventional applications, the well is often outfitted with chemical injection equipment to enhance ongoing recovery efforts without the requirement of intervention. For example, most of the well may be defined by a smooth steel casing that is configured for the rapid uphole transfer of hydrocarbons and other fluids from a formation. However, a buildup of irregular occlusive scale, wax and other debris may occur at the inner surface of the casing or tubing and other architecture so as to restrict flow. Such debris may even form over perforations in the casing, screen, or slotted pipe thereby also hampering hydrocarbon flow into the main borehole of the well from the surrounding formation.

[0004] In order to address the potential for scale and other buildup as noted above, time consuming interventional applications may be avoided through use of a circulating chemical injection system. With such systems in place, a metered amount of chemical mixture, such as a hydrochloric acid mix, may be near continuously circulated downhole to help prevent such buildup. This equipment includes an injection line that may be run from surface and directed at different downhole points of interest such as within production tubing, at a production screen or into formation fluid prior to entering the noted tubing. Regardless, the need to halt production or run expensive interventions in order to address undesirable buildup may be largely eliminated.

[0005] Unfortunately, unlike more interactive interventions, chemical injection faces a variety of limitations in terms of delivery. For example, the permanently installed hydraulic line generally terminates at a port below an area of concern such as the indicated production screen. However, this delivery is targeted at a single release point with the system relying on circulation of the delivered chemical mix in order to reach any other locations. Thus, even though a variety of locations may be of potential concern, only the target location is ensured of receiving the intended mix with a notable degree of precision.

[0006] With the limitations of single port delivery in mind, there are circumstances in which the delivery line is outfitted with multiple delivery ports such that delivery to more than one location is not limited to sole reliance on circulation. However, in these situations, the versatility of the delivery nevertheless remains limited. For example, where delivery is directed at multiple production zones, there may be particular zones of concern at one point in time and other zones of interest at other times. Yet, with a single delivery line available, each port delivers a predetermined rate of chemical mix when directed from surface equipment. That is to say, different ports at different locations are generally unable to activated while others are left closed. Rather, by way of a single delivery line, all ports are generally on or all are turned off.

[0007] Of course, it may be possible to provide a dedicated delivery line for each port which runs from surface equipment. In this manner, each line may be independently turned on or off at surface so as to allow for downhole ports to be independently activated. However, this type of system would require a dedicated delivery line for each and every port, thus, dramatically increasing completions equipment and installation expense.

[0008] As an alternative to providing a dedicated line running to each port where multiple ports are utilized, isolation techniques may be employed. That is, as in the case of stimulation and other zonally directed applications, different downhole zones may be isolated for sake of targeted delivery. In such cases, packers or other isolating downhole features may be employed as a means of targeting chemical injection delivery from multiple ports. For example, one downhole region may be isolated in a manner that prevents chemical delivery thereto while allowing such delivery elsewhere. Of course, again, shutting down production for sake of attaining isolation results in applications that are no more cost-effective or time saving than the original types of interventions which chemical injection systems are configured to help avoid.

[0009] Ultimately, dedicated delivery lines and isolation techniques are usually avoided. As a matter of time and cost, such options remain largely impractical. Thus, operators are generally left with reliance on single or multi-point chemical injection delivery which lacks any real measure of control over location specific delivery and/or adjustment thereto.

SUMMARY

[0010] A "smart" chemical injection assembly utilizing telemetry is provided. The assembly includes a mandrel housing coupled to a downhole tubular with an electric line that runs from an oilfield surface to the mandrel in a land well or offshore well. A fluid injection line is provided that also runs from the oilfield surface to the mandrel in a land well or offshore well. Further, a power telemetry module is coupled to the electric line. Thus, an electric actuator that is coupled to the injection line may be provided for governing fluid injection. Additionally, one or both of the module and the actuator may be secured within the mandrel housing.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] FIG. **1** is a side cross-sectional view of an embodiment of a telemetric chemical injection assembly disposed in a well.

[0012] FIG. 2A is an enlarged view of an embodiment of an injection sub of the assembly of FIG. 1 and corresponding downhole fluid flow.

[0013] FIG. 2B is an enlarged view of an alternate embodiment of an injection sub of the assembly with alternate corresponding downhole fluid flow.

[0014] FIG. 3 is an overview of an oilfield employing an embodiment of the assembly of FIG. 1 for tailored regulation of injection fluids at multiple well zones.

[0015] FIG. 4A is an alternate embodiment of the injection sub of FIG. 2B, equipped to accommodate a secondary injection line.

[0016] FIG. 4B is another alternate embodiment of the injection sub, outfitted with multiple injection valves.

[0017] FIG. 5 is a flow-chart summarizing an embodiment of employing a telemetric chemical injection assembly within a well.

DETAILED DESCRIPTION

[0018] Embodiments are described with reference to certain configurations of completions hardware that make use of chemical injection assemblies. In particular, completions are depicted and described which utilize a chemical injection assembly to help prevent scale and other buildup in a manner that may be telemetrically directed. For example, different injection points in different well locations may be independently directed from an oilfield surface even though a common injection line may be utilized. Of course, a variety of different completion architectures may benefit from utilization of such an injection assembly. For example, even a system utilizing a single injection point may benefit from telemetrically directed injection. Regardless, an injection sub (or mandrel housing) is provided that is equipped to accommodate either, or both, of an actuator valve to govern injection and a power module. Thus, the valve may be directly and independently powered and controlled via telemetric and fluid injection lines running thereto from surface.

[0019] Referring now to FIG. 1, a side cross-sectional view of an embodiment of a telemetric chemical injection assembly 100 is depicted within a well 180. In the embodiment shown, the assembly 100 makes up a portion of completions hardware that is disposed below casing 185 and a production packer 110. Further, the assembly 100 is positioned across multiple production regions 190, 195. More specifically, a zonal isolation packer 120 is provided about a production tubular 107. Thus, separate annular spaces 105, 106 adjacent the tubular 107 may be zonally isolated from one another whereas a common fluid channel 103 is defined within the tubular 107.

[0020] Zonal isolation at production regions 190, 195 as described above may allow for tailored recovery of production fluids. For example, the tubular 107 may be outfitted with a separate flow control valve 115, 116, exposed to the isolated annular space 105, 106. Thus, a hydraulic or other suitable control line 117 may be utilized to independently open or close the valves 115, 116. As such, production through a slotted liner 187, screen, perforated liner or similar hardware where utilized, at either formation region 190, 195 may be regulated via the open or closed valve 115, 116.

[0021] Continuing with reference to FIG. 1, each zonally isolated annular space 105, 106 is equipped with its own mandrel housing or injection sub 101, 102. As such, a chemical injection fluid mix may be directed at each space 105, 106, the liner 187 or other downhole hardware so as to impede production inhibiting buildup. In one embodiment, the mix may even be directed internally at the tubular channel 103 (see FIG. 2B). Regardless, while separate injection points 161, 163 are provided, independent control over the separate valves 160, 162 at each point 161, 163 is a different matter. That is, in the embodiment shown, the valves 160, 162 may be an electrically powered actuator of plunger, gas lift, solenoid valve, electric motor or other metering variety. Thus, rather than opening or closing alone, more precise delivery of chemical injection mix may be achieved. So, for example, the valves may include fully opened, fully closed and variable choke positions.

[0022] Further, while it might be possible to supply each valve 160, 162 with its own dedicated fluid line which may be controlled from the oilfield surface 300, this may be extremely cost prohibitive (see FIG. 3). Therefore, the embodiment of FIG. 1 reveals the use of a single injection line 150 routed to each valve 160, 162 in combination with a telemetric line 155 so as to more fully and practically take advantage of such tailored delivery.

[0023] The telemetric line 155 of FIG. 1 may be a conventional electric line or other suitable communication line for downhole use. In the embodiment shown, the line 155 is routed through a power telemetry module 170, 171 in order to supply the power for independently opening or closing each valve 160, 162 as directed. These modules 170, 171 are shown disposed within the subs 101, 102. However, in other embodiments, alternative locations may be utilized. Further, such modules 170, 171 may be made available for sake of monitoring and communicating downhole conditions such as pressure and/or temperature. Thus, an added feature of such modules 170, 171 may now be to advantageously serve as a supportive platform for independent powerable control over each valve 160, 162 in a “smart” fashion.

[0024] Referring now to FIG. 2A, an enlarged view of an embodiment of one of the injection subs 102 of the assembly of FIG. 1 is shown. In this depiction, fluid flow in the area is apparent. More specifically, production fluid 250 is shown moving uphole within the channel 103 of the production tubular 107 whereas injection fluid 200 is shown released from the valve 162 at the injection point 163. So, for example, the injection fluid 200 may serve to prevent occlusive buildup at the well formation interface of the slotted liner 187 and the depicted production region 195. Thus, when the flow control valve 116 is opened, production fluid 250 may flow substantially freely into the noted channel 103. Further, in one embodiment, an operator or control unit 310 may ensure that the flow control valve 116 is in an open or ‘choked’ position whenever the injection valve 162 is in an open position (see FIG. 3).

[0025] Continuing with reference to FIG. 2A, with added reference to FIG. 1, a shiftable member 216 of the flow control valve 116 may be directed to open the valve 116 by a conventional control line 117. For example, a conventional power/data cable may be utilized. However, opening of the injection valve 162 for sake of chemical injection delivery is two-fold. That is, the valve 162 may be supplied with the noted injection fluid 200 by way of the noted injection line 150. Further, tailored control over opening and/or the degree of opening of the valve 162 may be directed by another line (i.e. the telemetric line 155). While the injection and telemetry functions are split between two separate lines 150, 155, this type of layout allows for the use of a single injection line 150 across multiple subs 101, 102. That is, a tailored opening and/or closing of valves such as the injection valve **162** may be independently controlled. Therefore, even though only a single injection line **150** is utilized, the operator is not limited to an unintelligent injection of either all injection points **161**, **163** open or all closed.

[0026] As described above, the independent control over chemical injection delivery is directed through a telemetric line **155**. This may be a conventional electronic or other suitable cable. Once more, the line **155** may be routed from surface to a power telemetry module **171** as detailed above. That is, the module **171** may serve a function of acquiring and relaying data relative to temperature, pressure and perhaps other location-based well characteristics (note the exposed outlet to the tubular channel **103**). However, the module **171** may also advantageously serve the added function providing power and communicative relay to the injection valve **162** (note the electrical branch **255** of the line **155** routed to the valve **162**). Thus, independent control over the valve **162** may be exercised from the oilfield surface **300**. Indeed, with multiple modules **170**, **171** available, this same type of telemetric layout may be repeated at multiple downhole subs **101**, **102** (see FIG. **1**). As such, independent "intelligent" control over each valve **160**, **162** by way of a single main telemetric line **155** may be provided (see FIG. **3**).

[0027] Referring now to FIG. **2**B, an enlarged view of an alternate embodiment of the injection sub **102** is depicted. In this embodiment, the injection valve **162** and injection point **163** are reoriented so as to deliver injection fluid **200** within the channel **103** of the production tubing **107** as opposed to at the surrounding annular space **106**. For example, this may be advantageous where the sub **102** is located further uphole adjacent well casing **185**. That is, the fluid **200** may be directed at impeding buildup at internal tubular components as opposed to the slotted liner **187** as shown in FIG. **2**A. Regardless, the same intelligent, independently controllable manner of injection may be directed from the oilfield surface **300** of FIG. **3**.

[0028] Continuing now with reference to FIG. **3**, an overview of an oilfield **300** is shown, whereat an embodiment of the assembly **100** of FIG. **1** is disposed within a well **180**. More specifically, a more schematic view of the assembly **100** is shown allowing for tailored regulation of injection fluid **200** at different downhole production regions **190**, **195**. More specifically, production and chemical injection are both closed off relative the more downhole region **195**. For example, where water is being produced or for any number of other reasons, a determination may be made to effectively shut off the region **195**. Nevertheless, a determination to continue recovery of production fluids from points below the region **195** may also be made. Further, and perhaps more significantly in terms of the depicted figure, a determination may similarly be made to continue recovery and chemical injection at the other region **190**.

[0029] In the embodiment of FIG. **3**, chemical injection fluid **200** is delivered in the vicinity of one region **190** so as to inhibit buildup at the slotted liner or screen or perforated liner **187** as described above. This same fluid **200** is recovered within the tubular **107** along with production fluids **250** for transport uphole. The ability of the assembly **100** to efficiently recover these fluids **200**, **250** at one region **190** while keeping injection and recovery closed off from another region **195** is rendered practical and effective by the availability of cooperative valves **160**, **162** and modules **170**, **171** as detailed hereinabove (see FIG. **1**). Indeed, an electrically actuated plunger type valve **160**, **162** in conjunction with a readily available power telemetry module **170**, **171** may be particularly beneficial in allowing for the construction of such an assembly **100**.

[0030] Continuing with reference to FIG. **3**, an operator may intelligently direct chemical injection as detailed above through the use of surface equipment. More specifically, a control unit **310** may be provided for sake of directing operations, including the exercise of control over the telemetric line **155** and downhole valves as detailed above. Further, a chemical mix tank **320** may be provided for supplying of injection fluid **200** to the injection line **150**. Thus, later recovery of injection **200** and production **250** fluids may ultimately be routed through the well head **330** and a production line **340** for processing.

[0031] Referring now to FIG. **4**A, an alternate embodiment of the injection sub **102** and assembly **100** of FIG. **2**B is shown. In this embodiment, a secondary line **400** is routed to the location of the injection valve **162**. In this manner, a fluid other than the chemical injection fluid **200** may also be delivered through the valve **162**. That is, while fluid of any practical type may be directed through the injection line **150**, there may be circumstances in which different fluid types are segregated from one another. For example, an acid injection type of stimulation fluid may be delivered through the secondary line **400** at certain targeted points in time whereas the noted injection fluid **200** is delivered through the injection line **150** on a more regular or continuous basis.

[0032] Keeping fluids separated from one another may be desirable where the different fluids serve different applications, for example, different chemical injection and stimulation applications as noted above. However, it is worth noting that the added secondary line **400** is not required for sake of delivery to different injection points **161**, **163** (see FIG. **1**). Indeed, as depicted in FIG. **4**A, even though separate fluid types and lines **150**, **400** are provided, the same injection point **163** is ultimately utilized.

[0033] Referring now to FIG. **4**B, another alternate embodiment of the injection sub **102** is depicted. In this case, the sub **102** is outfitted with multiple injection valves **162**, **462**, **463** all drawing actuation from the same power telemetry module **171**. For example, note the electrical branch **255** running to the primary injection valve **162** as detailed above, as well as a secondary branch **455** splitting off to other secondary injection valves **462**, **463**.

[0034] In the embodiment of FIG. **4**B, the availability of multiple valves **162**, **462**, **463** allows for targeting of different delivery locations. That is, embodiments such as that depicted in FIG. **1** reveal different subs **101**, **102** at different depths being independently serviceable via a single injection line **150**. However, in FIG. **4**B another embodiment is shown that reveals the possibility of also servicing different locations at roughly the same depth of the same sub **102**. More specifically, the primary injection valve **162** is shown servicing the channel **103** at the interior of the production tubular **107** similar to the configuration of FIG. **2**B. Further, the secondary valves **462**, **463** are shown simultaneously servicing the annular space **106** similar to the configuration of FIG. **2**A.

[0035] Referring now to FIG. **5**, a flow-chart is shown summarizing an embodiment of employing a telemetric chemical injection assembly within a well. Namely, with the assembly installed as indicated at **510**, a chemical injection fluid may be selectively delivered through a line to any one of many injection points downhole (see **530**). Subsequently, over the same line, the fluid may be delivered to another of the points as indicated at **550**. Once more, as noted at **570**, these same injection points may be serviced by a secondary line for delivery of another fluid such as an acid-based stimulation fluid. Ultimately, over the course of such fluid delivery applications, the fluids may be recovered with production up to an oilfield surface as indicated at **590**.

[0036] Embodiments described hereinabove include a telemetric or "smart" chemical injection assembly which is able to provide targeted chemical injection at multiple downhole depths or locations in a tailored manner. That is, without the requirement of a multitude of individually dedicated chemical injection lines, multiple delivery locations may be independently regulated for delivery from an oilfield surface. Further, no intervening isolations are required in order to achieve such targeted or tailored delivery. Indeed, one downhole location may be opened and serviced while another remains turned off and vice versa. This may be achieved in a cost-effective manner through the use of available power telemetry modules.

[0037] The preceding description has been presented with reference to presently preferred embodiments. Persons skilled in the art and technology to which these embodiments pertain will appreciate that alterations and changes in the described structures and methods of operation may be practiced without meaningfully departing from the principle, and scope of these embodiments. Regardless, the foregoing description should not be read as pertaining only to the precise structures described and shown in the accompanying drawings, but rather should be read as consistent with and as support for the following claims, which are to have their fullest and fairest scope.

I claim:

1. A telemetric chemical injection assembly for disposal in a well at an oilfield, the assembly comprising:
- an injection sub;
- an actuator valve disposed within said sub to govern fluid injection therefrom;
- a power and telemetry module coupled to said valve;
- a telemetric line configured to run from a surface of the oilfield to said module; and
- a fluid injection line configured to run from a surface of the oilfield to said valve for the fluid injection.

2. The assembly of claim **1** wherein said module is disposed within said sub.

3. The assembly of claim **1** wherein said module serves as a monitor for well conditions.

4. The assembly of claim **3** wherein the well conditions include one of pressure and temperature.

5. The assembly of claim **1** wherein said actuator valve is electrically powered via said module.

6. The assembly of claim **1** wherein said actuator valve is selected from a group consisting of a plunger valve, a sliding sleeve, a gas lift valve, a solenoid valve, an electric motor and a metering valve.

7. The assembly of claim **1** wherein the fluid injection line is configured to supply a chemical injection fluid mix to said valve.

8. The assembly of claim **1** further comprising a secondary line configured to run from a surface of the oilfield to said valve for supplying of a secondary fluid.

9. The assembly of claim **8** wherein the secondary fluid is a stimulation fluid.

10. The assembly of claim **1** wherein said sub and said actuator valve are a first sub and a first actuator valve, the assembly further comprising a second actuator valve coupled to said injection line disposed within a second sub at a different depth of the well than said first sub.

11. The assembly of claim **1** wherein said valve is a first valve, the assembly further comprising a second valve coupled to said injection line within the sub.

12. A telemetric chemical injection system comprising for disposal in a well at an oilfield, the system comprising:
- a tubular with a channel running therethrough and disposed within the well, the well defined by multiple formation regions;
- a zonal isolation packer defining a first annulus thereabove and a second annulus therebelow, said packer positioned at a depth between at least portions of the regions;
- a first injection sub and power module coupled to said tubular within the first annulus;
- a second injection sub and power module coupled to said tubular within the second annulus;
- a telemetric line configured to run from a surface of the oilfield to said modules; and
- a fluid injection line configured to run from the oilfield surface to said subs.

13. The system of claim **12** further comprising:
- a first flow control valve incorporated into said tubular at a location of the first annulus; and
- a second flow control valve incorporated into said tubular at a location of the second annulus.

14. The system of claim **12** wherein said subs comprise actuator valves for delivery of fluid from the fluid injection line.

15. The system of claim **14** wherein the delivery is directed at one of the channel and a formation interface with the well.

16. A method of delivering chemical injection fluid to a well at an oilfield, the method comprising:
- directing an actuator valve to open from a surface of the oilfield over a telemetric line running therefrom:
- powering said directing through a power telemetry module coupled to the telemetric line and the valve; and
- supplying the fluid for the delivering through a fluid injection line coupled to the valve.

17. The method of claim **16** wherein the actuator valve is a first actuator valve, said directing further comprising maintaining closure of a second actuator valve coupled to the telemetric and fluid injection lines.

18. The method of claim **16** wherein the actuator valve is a first actuator valve, said directing further comprising opening a second actuator valve coupled to the telemetric and fluid injection lines.

19. The method of claim **16** further comprising supplying another fluid through a secondary injection line coupled to the valve for another application.

20. The method of claim **16** further comprising recovering fluids including the injection fluid through production to a surface at the oilfield.

* * * * *