

CLAIMS

1. A fluid flow control apparatus for use in an oilfield tubular positioned in a wellbore extending through a subterranean formation, the oilfield tubular for flowing fluid therethrough, the fluid having a density which changes over time, the apparatus comprising:
 - a tool housing;
 - a valve assembly having a valve housing with at least one inlet and at least one outlet;
 - a movable fluid diverter positioned in the tool housing, the fluid diverter actuated by change in the fluid density, the fluid diverter movable to restrict fluid flow through at least one valve inlet in response to change in the fluid density.
2. An apparatus as in claim 1 wherein the fluid diverter is of a preselected density and is buoyant in a fluid of a preselected density.
3. An apparatus as in claim 1 wherein the fluid diverter is movable between a first and a second position, and wherein the fluid diverter is biased towards a first position by a biasing member.
4. An apparatus as in claim 3 wherein the biasing member is a spring mechanism.
5. An apparatus as in claim 3 wherein the biasing member is a counterweight.
6. An apparatus as in claim 5 wherein the counterweight has a density different from the density of the fluid diverter.

7. An apparatus as in claim 6 wherein the counterweight is operably connected to the fluid diverter.
8. An apparatus as in claim 3 wherein the fluid diverter has a density greater than the fluid density during operation of the apparatus, the biasing mechanism offsetting the diverter density and allowing the diverter to be actuated by density change in the fluid.
9. An apparatus as in claim 1 wherein the movable fluid diverter pivots.
10. An apparatus as in claim 9 wherein the fluid diverter comprises a second valve assembly, wherein the diverter arm is operable to restrict flow through an inlet of a valve assembly.
11. An apparatus as in claim 9 wherein the at least one inlet of the valve assembly comprises a first inlet and a second inlet, and wherein the fluid diverter rotates between a first position in which the fluid diverter restricts fluid flow into the first inlet and second position in which the fluid diverter restricts fluid flow into the second inlet.
12. An apparatus as in claim 1 wherein the diverter is rotatable about a longitudinal axis.
13. An apparatus as in claim 12 wherein the fluid diverter rotates to a plurality of rotational angles, and wherein restriction of the fluid flow is related to the rotational angle of the fluid diverter.
14. An apparatus as in claim 12 further comprising a second valve assembly, each valve assembly having at least one inlet and at least one outlet, the fluid diverter operable to restrict flow into inlets of both of the valve assemblies when the fluid diverter is in the closed position.

15. An apparatus as in claim 1 further comprising an orientation selector assembly for orienting the valve assembly in the wellbore.
16. An apparatus as in claim 15 wherein the orientation selector assembly utilizes gravity to orient the valve assembly.
17. An apparatus as in claim 15 further comprising a stabilizer to maintain the valve assembly in its orientation.
18. An apparatus as in claim 16 wherein the stabilizer comprises a swellable elastomer.
19. An apparatus as in claim 1, further comprising an inflow control device, and wherein the valve inlet is in fluid communication with the inflow control device.
20. An apparatus as in claim 1 wherein the valve assembly further comprises spaced apart first and second inlets, and wherein the diverter is operable to change the fluid flow ratio between the first and second inlets in response to fluid density change.
21. An apparatus as in claim 20 wherein the change in fluid ratio is operable to actuate a valve member in the valve assembly.
22. An apparatus as in claim 21 wherein the valve assembly further comprises a valve chamber in fluid communication with the valve inlets and valve outlet, the valve chamber housing a valve member movable between a closed position wherein fluid flow through the valve outlet is restricted and an open position wherein fluid flow through the valve outlet is less restricted.

23. An apparatus as in claim 22 wherein the valve member is a pivotable valve arm having one end proximate the valve outlet and operable to restrict flow through the outlet.
24. An apparatus as in claim 21 wherein the valve assembly further comprises venturi pressure converter.
25. An apparatus as in claim 24 wherein the venturi pressure converter communicates pressure to the valve member thereby actuating the valve member.

26. A fluid flow control apparatus for use in an oilfield tubular positioned in a wellbore extending through a subterranean formation, the oilfield tubular for flowing fluid therethrough, the fluid having a density, the apparatus comprising:
- a fluid diverter movable in response to changes in the density of the fluid;
 - the fluid flow following a fluid flow path, wherein movement of the fluid diverter changes the fluid flow path; and
 - a valve assembly for restricting fluid flow, the valve assembly having an open and a closed position, wherein the change in the fluid flow path changes the position of the valve assembly.
27. An apparatus as in claim 26 wherein the fluid diverter is of a preselected density and is buoyant in a fluid of a preselected density.
28. An apparatus as in claim 26 wherein the fluid diverter is biased towards a first position by a biasing member.
29. An apparatus as in claim 28 wherein the biasing member is a spring mechanism.
30. An apparatus as in claim 28 wherein the biasing member is a counterweight.
31. An apparatus as in claim 30 wherein the counterweight has a density different from the density of the fluid diverter.
32. An apparatus as in claim 28 wherein the fluid diverter has a density greater than the fluid density during operation of the apparatus, the biasing mechanism offsetting the diverter density and allowing the diverter to be actuated by density change in the fluid.

33. An apparatus as in claim 26 wherein the fluid diverter is movable by rotating about a rotational axis, movement about the rotational axis changing the fluid flow path.
34. An apparatus as in claim 26 wherein the fluid diverter is movable by pivoting about a pivot.
35. An apparatus as in claim 26 wherein the valve assembly further comprises spaced apart first and second inlets, and wherein the diverter is operable to change the fluid flow ratio between the first and second inlets in response to fluid density change.
36. An apparatus as in claim 35 wherein the change in fluid ratio is operable to actuate a valve member in the valve assembly.
37. An apparatus as in claim 26 wherein the apparatus further comprises a housing, the fluid diverter movably mounted in the housing, the fluid flow path defined by fluid flow along the housing and adjacent the fluid diverter.
38. An apparatus as in claim 37 wherein the valve assembly comprises at least one inlet and at least one outlet, and wherein the fluid flow path is defined in part by the at least one inlet and outlet.
39. An apparatus as in claim 37 wherein the fluid diverter is movable from a first position adjacent a first valve assembly inlet and a second position adjacent a second valve assembly inlet.

40. A fluid flow control apparatus for use in an oilfield tubular positioned in a wellbore extending through a subterranean formation, the oilfield tubular for flowing fluid therethrough, the apparatus comprising:
- a tubular member defining a passageway for fluid to flow through;
 - a valve assembly having at least one inlet;
 - a flow control assembly mounted for rotational movement in the tubular member, fluid flow imparting rotation to the flow control assembly;
 - the flow control assembly having a restriction member for restricting flow through the inlet of the valve assembly.
41. An apparatus as in claim 40, the restriction member mounted to move longitudinally in the tubular member.
42. An apparatus as in claim 41 wherein the restriction member moves between an open position wherein flow through the valve inlet is not restricted and a closed position wherein flow through the valve inlet is restricted.
43. An apparatus as in claim 40 wherein the rotation rate of the flow control assembly is in relation to change in a fluid flow characteristic.
44. An apparatus as in claim 43 wherein the fluid flow characteristic is viscosity.
45. An apparatus as in claim 41 wherein the flow control assembly further comprises a plurality of balance members, the balance members mounted for radial movement in response to rotation of the flow control assembly.
46. An apparatus as in claim 45 wherein the balance members are pivotally mounted to move radially in response to rotation of the fluid control assembly.

47. An apparatus as in claim 46 wherein radial movement of the balance members causes longitudinal movement of the restriction member.

48. An apparatus as in claim 44 wherein the fluid flow through the valve is restricted when the fluid reaches a preselected viscosity.

49. An apparatus as in claim 48 wherein the fluid flow is restricted at a relatively low viscosity and fluid flow is not restricted at a relatively high viscosity.

CLAIMS

1. A fluid flow control apparatus for use in an oilfield tubular positioned in a wellbore extending through a subterranean formation, the oilfield tubular for flowing fluid therethrough, the fluid having a density which changes over time, the apparatus comprising:
 - a tool housing;
 - a valve assembly having a valve housing with a plurality of valve inlets and at least one valve outlet;
 - a movable fluid diverter positioned in the tool housing, the fluid diverter actuated by change in the fluid diverter buoyancy in response to change in the fluid density, the fluid diverter moveable between the plurality of valve inlets to restrict fluid flow through at least one valve inlet in response to change in the fluid density.
2. The apparatus as in claim 1 wherein the fluid diverter is of a preselected density and is buoyant in a fluid of a preselected density.
3. The apparatus as in claim 1 wherein the fluid diverter is movable between a first and a second position, and wherein the fluid diverter is biased towards a first position by a biasing member.
4. The apparatus as in claim 3 wherein the biasing member is a spring mechanism.
5. The apparatus as in claim 3 wherein the fluid diverter has a density greater than the fluid density of operation of the apparatus, the biasing mechanism offsetting the fluid diverter density and allowing the diverter to be actuated by density change in the fluid.
6. The apparatus as in claim 1 wherein the movable fluid diverter pivots about a lateral axis.

7. The apparatus as in claim 1 wherein the valve assembly further comprises spaced apart first and second inlets, and wherein the diverter is operable to change a fluid flow ratio between the first and second inlets in response to fluid density change.
8. The apparatus as in claim 7 wherein the change in the fluid flow ratio is operable to actuate a valve member in the valve assembly.
9. The apparatus as in claim 8 wherein the valve assembly further comprises a valve chamber in fluid communication with the valve inlets and valve outlet, the valve chamber housing the valve member, the valve member movable between a closed position wherein fluid flow through the valve outlet is restricted and an open position wherein fluid flow through the valve outlet is less restricted.
10. The apparatus as in claim 9 wherein the valve member is a pivotable valve arm having one end proximate the valve outlet and operable to restrict flow through the outlet.
11. The apparatus as in claim 8 wherein the valve assembly further comprises venturi pressure converter.
12. The apparatus as in claim 11 wherein the venturi pressure converter communicates pressure to the valve member thereby actuating the valve member.
13. A fluid flow control apparatus for use in an oilfield tubular positioned in a wellbore extending through a subterranean formation, the oilfield tubular for flowing fluid therethrough, the fluid having a density which changes over time, the apparatus comprising:
 - a fluid diverter movable in response to changes in the density of the fluid;
 - the fluid flow following a fluid flow path, wherein movement of the fluid diverter changes the fluid flow path; and

a valve assembly having a valve housing with a plurality of valve inlets and at least one valve outlet for restricting fluid flow, the valve assembly having an open and a closed position, wherein the change in the fluid flow path changes the position of the valve assembly; and

wherein the fluid diverter movable between the plurality of valve inlets to restrict fluid flow through at least one valve inlet.

14. The apparatus as in claim 13 wherein the fluid diverter is of a preselected density and is buoyant in a fluid of a preselected density.

15. The apparatus as in claim 13 wherein the fluid diverter is biased towards a first position by a biasing member.

16. The apparatus as in claim 15 wherein the biasing member is a spring mechanism.

17. The apparatus as in claim 15 wherein the fluid diverter has a density greater than the fluid density during operation of the apparatus, the biasing mechanism offsetting the diverter density and allowing the diverter to be actuated by density change in the fluid.

18. The apparatus as in claim 13 wherein the fluid diverter is movable by pivoting about a pivot.

19. The apparatus as in claim 13 wherein the valve assembly further comprises spaced apart first and second inlets, and wherein the diverter is operable to change the fluid flow ratio between the first and second inlets in response to fluid density change.

20. The apparatus as in claim 19 wherein the change in fluid flow ratio is operable to actuate a valve member in the valve assembly.

21. The apparatus as in claim 13 wherein the apparatus further comprises a housing, the fluid diverter movably mounted in the housing, the fluid flow path defined by fluid flow along the housing and adjacent the fluid diverter.
22. The apparatus as in claim 21 wherein the valve assembly comprises at least one inlet and at least one outlet, and wherein the fluid flow path is defined in part by the at least one inlet and outlet.
23. The apparatus as in claim 21 wherein the fluid diverter is movable from a first position adjacent a first valve assembly inlet and a second position adjacent a second valve assembly inlet.
24. A fluid flow control apparatus for use in an oilfield tubular positioned in a wellbore extending through a subterranean formation, the oilfield tubular for flowing fluid therethrough, the fluid having a density which changes over time, the apparatus comprising:
- a tool housing;
 - a valve assembly positioned in the tool housing and having a valve housing with at least one inlet and at least one outlet;
 - a rotatable fluid diverter positioned in the tool housing and adjacent the exterior of the valve housing, the fluid diverter rotated about a longitudinal axis of the fluid diverter by change in the fluid diverter buoyancy in response to change in the fluid density, the fluid diverter rotatable to restrict fluid flow through at least one valve inlet in response to change in the fluid density.
25. The apparatus as in claim 24 wherein the fluid diverter is of a preselected density and is buoyant in a fluid of a preselected density.
26. The apparatus as in claim 24 wherein the fluid diverter is movable between a first and a second position, and wherein the fluid diverter is biased towards a first position by a biasing member.

27. The apparatus as in claim 26 wherein the biasing member is a counterweight.
28. The apparatus as in claim 27 wherein the counterweight has a density different from the density of the fluid diverter.
29. The apparatus as in claim 28 wherein the counterweight is operably connected to the fluid diverter.
30. The apparatus as in claim 26 wherein the fluid diverter has a density greater than the fluid density during operation of the apparatus, the biasing mechanism offsetting the diverter density and allowing the diverter to be actuated by density change in the fluid.
31. The apparatus as in claim 24 wherein the fluid diverter comprises a second valve assembly, wherein the diverter arm is operable to restrict flow through an inlet of a valve assembly.
32. The apparatus as in claim 24 wherein the at least one inlet of the valve assembly comprises a first inlet and a second inlet, and wherein the fluid diverter rotates between a first position in which the fluid diverter restricts fluid flow into the first inlet and second position in which the fluid diverter restricts fluid flow into the second inlet.
33. The apparatus as in claim 24 wherein the fluid diverter rotates to a plurality of rotational angles, and wherein restriction of the fluid flow is related to the rotational angle of the fluid diverter.
34. The apparatus as in claim 33 further comprising a second valve assembly having a second valve housing, each valve housing having at least one inlet and at least one outlet, the fluid diverter in the closed position operable to restrict flow into

inlets of both of the valve assemblies.

35. The apparatus as in claim 24 further comprising a self-orienting valve assembly for orienting the valve assembly in the wellbore.

36. The apparatus as in claim 35 wherein the self-orienting valve assembly utilizes gravity to orient the valve assembly.

37. The apparatus as in claim 36 wherein the sealing agent comprises a swellable elastomer.

38. The apparatus as in claim 35 further comprising a sealing agent to maintain the valve assembly in an orientation.

39. The apparatus as in claim 24, further comprising an inflow control device, and wherein the valve inlet is in fluid communication with the inflow control device.

40. The apparatus as in claim 24 wherein the valve assembly further comprises spaced apart first and second inlets, and wherein the diverter is operable to change the fluid flow ratio between the first and second inlets in response to fluid density change.

41. The apparatus as in claim 40 wherein the change in fluid flow ratio is operable to actuate a valve member in the valve assembly.

42. The apparatus as in claim 41 wherein the valve assembly further comprises a valve chamber in fluid communication with the valve inlets and valve outlet, the valve chamber housing the a valve member, the valve member movable between a closed position wherein fluid flow through the valve outlet is restricted and an open position wherein fluid flow through the valve outlet is less restricted.

43. The apparatus as in claim 42 wherein the valve member is a pivotable valve

arm having one end proximate the valve outlet and operable to restrict flow through the outlet.

44. The apparatus as in claim 41 wherein the valve assembly further comprises venturi pressure converter.

45. A fluid flow control apparatus for use in an oilfield tubular positioned in a wellbore extending through a subterranean formation, the oilfield tubular for flowing fluid therethrough, the fluid having a density, the apparatus comprising:

a fluid diverter rotationally movable about a longitudinal rotational axis of the fluid diverter in response to changes in the density of the fluid, wherein movement of the fluid diverter changes a fluid flow path through the apparatus; and

a valve assembly positioned adjacent the fluid diverter for restricting fluid flow through the valve assembly, the valve assembly having an open and a closed position, and wherein the position of the valve assembly changes in response to changes to the fluid flow path.

46. The apparatus as in claim 45 wherein the fluid diverter is of a preselected density and is buoyant in a fluid of a preselected density.

47. The apparatus as in claim 45 wherein the fluid diverter is biased towards a first position by a biasing member.

48. The apparatus as in claim 47 wherein the biasing member is a counterweight.

49. The apparatus as in claim 48 wherein the counterweight has a density different from the density of the fluid diverter.

50. The apparatus as in claim 47 wherein the fluid diverter has a density greater than the fluid density during operation of the apparatus, the biasing mechanism offsetting the diverter density and allowing the diverter to be rotated by density

change in the fluid.

51. The apparatus as in claim 45 wherein the apparatus further comprises a housing, the fluid diverter movably mounted in the housing, the fluid flow path defined by fluid flow along the housing and adjacent the fluid diverter.

52. The apparatus as in claim 51 wherein the valve assembly comprises at least one inlet and at least one outlet, and wherein the fluid flow path is defined in part by the at least one inlet and outlet.

53. The apparatus as in claim 51 wherein the fluid diverter is movable from a first position adjacent a first valve assembly inlet and a second position adjacent a second valve assembly inlet.

54. A fluid flow control apparatus for use in an oilfield tubular positioned in a wellbore extending through a subterranean formation, the oilfield tubular for flowing fluid therethrough, the fluid having a density which changes over time, the apparatus comprising:

- a tool housing;

- a valve assembly positioned in the tool housing, the valve assembly having an inlet, an outlet, and a movable valve member, the movable valve member movable between a closed position wherein fluid flow through the valve assembly is restricted and an open position in which fluid flow through the valve assembly is relatively unrestricted; and

- a movable fluid diverter positioned at an end of the valve assembly, the movable fluid diverter movable in response to change in the fluid density, the movable fluid diverter movable between a first position and a second position, the movable fluid diverter for changing the fluid flow pattern in the valve assembly, wherein the movable fluid diverter pivots, and wherein the movable valve member moves between the closed and open positions in response to movement of the movable fluid diverter between the first and second positions and change in the fluid flow pattern in the valve

assembly.

55. The apparatus as in claim 54 wherein the movable fluid diverter is of a preselected density and is buoyant in a fluid of a preselected density.

56. The apparatus as in claim 54 wherein the movable fluid diverter is biased towards one of the first or second positions by a biasing member.

57. The apparatus as in claim 54 wherein the tool housing is a tubular tool housing.

58. The apparatus as in claim 54 wherein the movable fluid diverter is operable to alter a fluid flow pattern through the tool housing.

59. The apparatus as in claim 58 wherein the movable fluid diverter, when in the first position, substantially restricts flow along a bottom portion of the tool housing.

60. The apparatus as in claim 59 wherein the tool housing is substantially cylindrical and the movable fluid diverter has a cross-section other than cylindrical.

61. The apparatus as in claim 54 wherein the movable fluid diverter has a first and second end, and wherein the first end is pivotally attached to the tool housing.

62. The apparatus as in claim 61 wherein the movable valve member is pivotally mounted in the tool housing.

63. The apparatus as in claim 62 wherein the valve assembly is a flapper valve assembly.

64. The apparatus as in claim 62 further comprising a fluid outlet defined in the

tool housing, the movable valve member movable to restrict fluid flow through the fluid outlet.

65. A method of fluid flow control for use in an oilfield tubular positioned in a wellbore extending through a subterranean formation, the oilfield tubular for flowing fluid therethrough, the fluid having a characteristic which changes over time, the apparatus comprising:

- flowing fluid through a first and second passageways positioned in a housing, the flow defining a flow ratio;

- flowing fluid through an outlet positioned in the housing;

- varying resistance to fluid flow through at least one of the first and second passageways, the resistance variation dependent on change in the fluid characteristic;

- changing the flow ratio in response to varying the resistance through at least one of the first and second passageways;

- moving a valve element positioned in the housing in response to changing the flow ratio;

- restricting fluid flow through the outlet in response to moving the valve element; and

- moving a fluid restrictor arm adjacent the outlet in response to movement of the valve element, wherein the valve element has a first arm positioned adjacent the first passageway and a second arm positioned adjacent the second passageway.

66. The method as in claim 65 wherein the fluid characteristic is one of viscosity, density, or flow rate.

67. The method as in claim 65 wherein the valve element biased towards a position.

68. The method as in claim 65 wherein the valve element pivots.

69. The method as in claim 65, further comprising the step of completely

restricting fluid flow through the outlet in response to movement of the fluid restrictor adjacent the outlet.

70. The method as in claim 65 further comprising rotating the valve element.

71. A fluid flow control apparatus for use in an oilfield tubular positioned in a wellbore extending through a subterranean formation, the oilfield tubular for flowing fluid therethrough, the apparatus comprising:

- a tubular defining a fluid passageway;

- a port positioned in the passageway;

- a rotational, fluid-driven valve member, the valve member mounted for rotation about a longitudinal axis in the passageway, fluid flow through the fluid passageway imparting rotation to the valve member, wherein the valve member comprises a plurality of balance members mounted for radial movement in response to rotation of the valve member; and

- a valve restriction member movably mounted to the valve member and movable to restrict flow through the port.

72. The apparatus as in claim 71, the valve restriction member mounted to move longitudinally in the tubular passageway.

73. The apparatus as in claim 72, wherein the valve restriction member moves between an open position wherein flow through the port is unrestricted and a closed position wherein flow through the port is restricted.

74. The apparatus as in claim 71, wherein the rotation rate of the valve member is responsive to changes in a fluid flow characteristic.

75. The apparatus as in claim 74, wherein the fluid flow characteristic is viscosity, velocity, flow rate, or density.

76. The apparatus as in claim 75, wherein fluid flow through the port is restricted when the fluid reaches a preselected viscosity.

77. The apparatus as in claim 76, wherein the fluid flow is restricted at a lower viscosity and fluid flow is unrestricted at a higher viscosity.

78. The apparatus as in claim 71, wherein the balance members are pivotally mounted to move radially in response to rotation of the valve member.

79. The apparatus as in claim 71, wherein radial movement of the balance members causes longitudinal movement of the valve restriction member.

80. The apparatus as in claim 71, wherein the valve restriction member moves in response to centrifugal force exerted on the valve member.