

CLAIMS

1. A bidirectional downhole fluid flow control system comprising:

at least one injection flow control component having direction dependent flow resistance, wherein the at least one injection flow control component comprises a fluidic diode providing greater resistance to flow in a production direction than in an injection direction in series with a fluid selector valve; and

at least one production flow control component in parallel with the at least one injection flow control component and having direction dependent flow resistance,

wherein, injection fluid flow experiences a greater flow resistance through the at least one production flow control component than through the at least one injection flow control component; and

wherein, production fluid flow experiences a greater flow resistance through the at least one injection flow control component than through the at least one production flow control component.

2. The flow control system as recited in claim 1 wherein the at least one injection flow control component further comprises a fluidic diode providing greater resistance to flow in the production direction than in the injection direction.

3. The flow control system as recited in claim 1 wherein the at least one production flow control component further comprises a fluidic diode providing greater resistance to flow in the injection direction than in the production direction.

4. The flow control system as recited in claim 1 wherein the at least one injection flow control component further comprises a vortex diode wherein injection fluid flow entering the

vortex diode travels primarily in a radial direction and wherein production fluid flow entering the vortex diode travels primarily in a tangential direction.

5. The flow control system as recited in claim 1 wherein the at least one production flow control component further comprises a vortex diode wherein production fluid flow entering the vortex diode travels primarily in a radial direction and wherein injection fluid flow entering the vortex diode travels primarily in a tangential direction.

6. The flow control system as recited in claim 1 wherein the at least one injection flow control component further comprises a fluidic diode providing greater resistance to flow in the production direction than in the injection direction in series with a nozzle having a throat portion and a diffuser portion operable to enable critical flow therethrough.

7. The flow control system as recited in claim 1 wherein the at least one production flow control component further comprises a fluidic diode providing greater resistance to flow in the injection direction than in the production direction in series with an inflow control device.

8. A bidirectional downhole fluid flow control system comprising:

at least one injection vortex diode in series with a fluid selector valve wherein injection fluid flow entering the injection vortex diode travels primarily in a radial direction and wherein production fluid flow entering the injection vortex diode travels primarily in a tangential direction; and

at least one production vortex diode in parallel with the at least one injection vortex diode wherein production fluid flow entering the production vortex diode travels primarily in a radial direction and wherein injection fluid flow entering the production vortex diode travels primarily in a tangential direction.

9. The flow control system as recited in claim 8 wherein the at least one injection vortex diode is in series with a nozzle having a throat portion and a diffuser portion operable to enable critical flow therethrough.

10. The flow control system as recited in claim 8 wherein the at least one production vortex diode is in series with an inflow control device.

11. The flow control system as recited in claim 8 wherein the at least one injection vortex diode further comprises a plurality of injection vortex diodes in parallel with each other.

12. The flow control system as recited in claim 8 wherein the at least one production vortex diode further comprises a plurality of production vortex diodes in parallel with each other.

13. A bidirectional downhole fluid flow control method comprising:

providing a fluid flow control system at a target location downhole, the fluid flow control system having at least one injection flow control component and at least one production flow control component in parallel with the at least one injection flow control component;

pumping an injection fluid from the surface into a formation through an injection fluid diode having direction dependent flow resistance and a nozzle in series with the fluid diode of the fluid flow control system, the nozzle having a throat portion and a diffuser portion operable to enable critical flow therethrough, such that the injection fluid experiencing greater flow resistance through the production flow control component than through the injection flow control component; and producing a formation fluid to the surface through the fluid flow control system such that the production fluid experiencing greater flow resistance through the injection flow control component than through the production flow control component.

14. The method as recited in claim 13 wherein pumping the injection fluid from the surface into the formation through the fluid flow control system further comprises pumping the

injection fluid through parallel opposing fluid diodes, each having direction dependent flow resistance.

15. The method as recited in claim 13 wherein producing the formation fluid to the surface through the fluid flow control system further comprises producing the formation fluid through parallel opposing fluid diodes, each having direction dependent flow resistance.

16. The method as recited in claim 13 wherein pumping the injection fluid from the surface into a formation through the fluid flow control system further comprises pumping the injection fluid through parallel opposing vortex diodes, each having direction dependent flow resistance.

17. The method as recited in claim 13 wherein producing the formation fluid to the surface through the fluid flow control system further comprises producing the formation fluid through parallel opposing vortex diodes, each having direction dependent flow resistance.

18. A bidirectional downhole fluid flow control system comprising:

at least one injection flow control component having direction dependent flow resistance;
and

at least one production flow control component in parallel with the at least one injection flow control component, the at least one production flow control component comprising an inflow control device,

wherein, inflow of production fluid experiences a greater flow resistance through the at least one injection flow control component than outflow of injection fluid through the at least one injection flow control component.

19. The flow control system as recited in claim 18 wherein the at least one production flow control has direction dependent flow resistance wherein outflow of injection fluid

experiences a greater flow resistance through the at least one production flow control component than inflow of production fluid through the at least one production flow control component.

20. The flow control system as recited in claim 18 wherein the at least one injection flow control component further comprises a vortex diode wherein injection fluid flow entering the vortex diode travels primarily in a radial direction and wherein production fluid flow entering the vortex diode travels primarily in a tangential direction.

21. The flow control system as recited in claim 18 wherein the at least one injection flow control component further comprises a fluidic diode providing greater resistance to flow in the production direction than in the injection direction in series with a nozzle having a throat portion and a diffuser portion operable to enable critical flow therethrough.

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1. A bidirectional downhole fluid flow control system comprising:

at least one injection flow control component having direction dependent flow resistance, wherein the at least one injection flow control component comprises a fluidic diode providing greater resistance to flow in a production direction than in an injection direction in series with a fluid selector valve; and

at least one production flow control component in parallel with the at least one injection flow control component and having direction dependent flow resistance,

wherein, injection fluid flow experiences a greater flow resistance through the at least one production flow control component than through the at least one injection flow control component; and

wherein, production fluid flow experiences a greater flow resistance through the at least one injection flow control component than through the at least one production flow control component.

2. The flow control system as recited in claim 1 wherein the at least one production flow control component further comprises a fluidic diode providing greater resistance to flow in the injection direction than in the production direction.

3. The flow control system as recited in claim 1 wherein the at least one injection flow control component further comprises a vortex diode wherein injection fluid flow entering the vortex diode travels primarily in a radial direction and wherein production fluid flow entering the vortex diode travels primarily in a tangential direction.

4. The flow control system as recited in claim 1 wherein the at least one production flow control component further comprises a vortex diode wherein production fluid flow entering the

vortex diode travels primarily in a radial direction and wherein injection fluid flow entering the vortex diode travels primarily in a tangential direction.

5. The flow control system as recited in claim 1 wherein the at least one injection flow control component further comprises a fluidic diode providing greater resistance to flow in the production direction than in the injection direction in series with a nozzle having a throat portion and a diffuser portion operable to enable critical flow therethrough.

6. The flow control system as recited in claim 1 wherein the at least one production flow control component further comprises a fluidic diode providing greater resistance to flow in the injection direction than in the production direction in series with an inflow control device.

7. A bidirectional downhole fluid flow control system comprising:

at least one injection vortex diode in series with a fluid selector valve wherein injection fluid flow entering the injection vortex diode travels primarily in a radial direction and wherein production fluid flow entering the injection vortex diode travels primarily in a tangential direction; and

at least one production vortex diode in parallel with the at least one injection vortex diode wherein production fluid flow entering the production vortex diode travels primarily in a radial direction and wherein injection fluid flow entering the production vortex diode travels primarily in a tangential direction.

8. The flow control system as recited in claim 7 wherein the at least one injection vortex diode is in series with a nozzle having a throat portion and a diffuser portion operable to enable critical flow therethrough.

9. The flow control system as recited in claim 7 wherein the at least one production vortex diode is in series with an inflow control device.

10. The flow control system as recited in claim 7 wherein the at least one injection vortex diode further comprises a plurality of injection vortex diodes in parallel with each other.

11. The flow control system as recited in claim 7 wherein the at least one production vortex diode further comprises a plurality of production vortex diodes in parallel with each other.

12. A bidirectional downhole fluid flow control method comprising:

providing a fluid flow control system at a target location downhole, the fluid flow control system having at least one injection flow control component and at least one production flow control component in parallel with the at least one injection flow control component;

pumping an injection fluid from the surface into a formation through an injection fluid diode having direction dependent flow resistance and a nozzle in series with the fluid diode of the fluid flow control system, the nozzle having a throat portion and a diffuser portion operable to enable critical flow therethrough, such that the injection fluid experiencing greater flow resistance through the production flow control component than through the injection flow control component; and producing a formation fluid to the surface through the fluid flow control system such that the production fluid experiencing greater flow resistance through the injection flow control component than through the production flow control component.

13. The method as recited in claim 12 wherein pumping the injection fluid from the surface into the formation through the fluid flow control system further comprises pumping the injection fluid through parallel opposing fluid diodes, each having direction dependent flow resistance.

14. The method as recited in claim 12 wherein producing the formation fluid to the surface through the fluid flow control system further comprises producing the formation fluid through parallel opposing fluid diodes, each having direction dependent flow resistance.

15. The method as recited in claim 12 wherein pumping the injection fluid from the surface into a formation through the fluid flow control system further comprises pumping the injection fluid through parallel opposing vortex diodes, each having direction dependent flow resistance.

16. The method as recited in claim 12 wherein producing the formation fluid to the surface through the fluid flow control system further comprises producing the formation fluid through parallel opposing vortex diodes, each having direction dependent flow resistance.

17. A bidirectional downhole fluid flow control system comprising:

at least one injection flow control component having direction dependent flow resistance;
and

at least one production flow control component in parallel with the at least one injection flow control component, the at least one production flow control component comprising an inflow control device,

wherein, inflow of production fluid experiences a greater flow resistance through the at least one injection flow control component than outflow of injection fluid through the at least one injection flow control component.

18. The flow control system as recited in claim 17 wherein the at least one production flow control has direction dependent flow resistance wherein outflow of injection fluid experiences a greater flow resistance through the at least one production flow control component than inflow of production fluid through the at least one production flow control component.

19. The flow control system as recited in claim 17 wherein the at least one injection flow control component further comprises a vortex diode wherein injection fluid flow entering the vortex diode travels primarily in a radial direction and wherein production fluid flow entering the vortex diode travels primarily in a tangential direction.

20. The flow control system as recited in claim 17 wherein the at least one injection flow control component further comprises a fluidic diode providing greater resistance to flow in the production direction than in the injection direction in series with a nozzle having a throat portion and a diffuser portion operable to enable critical flow therethrough.