

CLAIMS

1. A flow control device for regulating the flow of fluid from a hydrocarbon-containing reservoir to a production conduit, the flow control device configured for fluid communication with the production conduit, and the flow control device comprising:

an inlet for receiving reservoir fluid from the hydrocarbon-containing reservoir and communicating fluidly with a first fluid-conducting passage;

the first fluid-conducting passage having a first cross-sectional diameter, the first cross-sectional diameter being substantially constant along the first fluid-conducting passage;

a second fluid-conducting passage for communicating fluidly with the first fluid-conducting passage and having a second cross-sectional diameter, the second cross-sectional diameter being substantially constant along the second fluid-conducting passage and greater than the first cross-sectional diameter at a defined ratio; and

the second fluid-conducting passage having a length that is proportional to the first cross-sectional diameter.

2. The flow control device of claim 1, wherein the defined ratio is 3:1.

3. The flow control device of claim 1, wherein the defined ratio is 2:1.

4. The flow control device of claim 1, wherein the length of the second fluid-conducting passage is at least 10X greater than the first cross-sectional diameter.

5. The flow control device of claim 1, wherein the length of the second fluid-conducting passage is 20X to 50X greater than the first cross-sectional diameter.

6. The flow control device of claim 1, wherein the flow control device comprises a transition passage connecting the first fluid-conducting passage at one end and the second fluid-conducting passage at the other end, the one end of the transition passage having substantially the same cross-sectional flow area as that of the first fluid-conducting passage and the other end of the transition passage having substantially the same cross-sectional flow area as that of the second fluid-conducting passage.

7. The flow control device of claim 6, wherein the transition passage extends from the one end to the other end at an angle of 1.5 degrees relative to the flow control device's central longitudinal axis.

8. The flow control device of claim 6, wherein the transition passage extends from the one end to the other end at an angle between 0.5 degrees and 30 degrees relative

to the flow control
device's central longitudinal axis.

9. The flow control device of claim 6, wherein the transition passage
extends from the one
end to the other end smoothly.

10. The flow control device of claim 6, wherein the first fluid-conducting
passage
transitions to the second fluid-conducting passage in a step change.

11. The flow control device of claim 1, comprising a curved entry passage
positioned
between the inlet and the first fluid-conducting passage.

12. The flow control device of claim 1, wherein the curved entry passage
comprises a smooth
surface extending from the inlet to the first fluid-conducting passage.

13. The flow control device of claim 1, wherein the first cross-sectional
diameter is 3mm.

14. The flow control device of claim 1, wherein the first cross-sectional
diameter is in the range
between 2mm and 5mm.

15. The flow control device of claim 13, wherein the second cross-sectional
diameter is 6mm.

16. The flow control device of claim 1, wherein the first fluid-conducting
passage has a length
in the range between 7mm and 10mm.

17. The flow control device of claim 1, wherein the production conduit is
configured for steam
assisted gravity drainage operation.

18. A system for the production of fluid from a hydrocarbon-containing
reservoir,
comprising:
a production conduit for producing fluids from a hydrocarbon-containing
reservoir using
steam assisted gravity drainage;
a flow control device for regulating the flow of fluid from the hydrocarbon-
containing

reservoir to the production conduit, the flow control device in fluid communication with the production conduit, and the flow control device comprising:

an inlet for receiving reservoir fluid from the hydrocarbon-containing reservoir and communicating fluidly with a first fluid-conducting passage; the first fluid-conducting passage having a first cross-sectional diameter, the first cross-sectional diameter being substantially constant along the first fluid-conducting passage and at least 3mm; a second fluid-conducting passage in fluid communication with the first fluid-conducting passage and having a second cross-sectional diameter, the second cross-sectional diameter being substantially constant along the second fluid-conducting passage and greater than the first cross-sectional diameter at a defined ratio that is at least 3:1; the second fluid-conducting passage having a length that is at least 20X the first cross-sectional diameter; and a curved entry passage positioned between the inlet and the first fluid-conducting passage.

19. A method of producing heavy oil from an oil sands reservoir, comprising:
injecting a fluid into the reservoir such that heavy oil is mobilized, and a reservoir fluid mixture, including heavy oil and condensed hot water, is generated, conducting the reservoir fluid mixture through a first fluid-conducting passage such that the hot water of the reservoir fluid mixture is accelerated, resulting in a concomitant pressure decrease sufficient to effect vaporization of at least a fraction of the hot water, the first fluid-conducting passage having a first cross-sectional diameter and the first cross-sectional diameter being substantially constant along the first fluid-conducting passage; conducting the vaporized water through a second fluid-conducting passage and to the production conduit, the second fluid-conducting passage having a second cross-sectional diameter, the second cross-sectional diameter being substantially constant along the second fluid-conducting passage and greater than the first cross-sectional diameter at a defined ratio, and the second fluid-conducting passage having a length that is proportional to the first cross-sectional diameter; and recovering at least the heavy oil from the production conduit.

20 The method of claim 19 wherein the defined ratio is 3:1.

21. The method of claim 19 wherein the defined ratio is 2:1.

22. The method of claim 19 wherein the length of the second fluid-conducting passage is at least 10X greater than the first cross-sectional diameter.

23. The method of claim 19 wherein the length of the second fluid-conducting passage is 20X to 50X greater than the first cross-sectional diameter.

24. The method of claim 19 wherein the flow control device comprises a transition passage connecting the first fluid-conducting passage at one end and the second fluid-conducting passage at the other end, the one end of the transition passage having substantially the same cross-sectional flow area as that of the first fluid-conducting passage and the other end of the transition passage having substantially the same cross-sectional flow area as that of the second fluid-conducting passage.

25. The method of claim 24 wherein the transition passage extends from the one end to the other end at an angle of 1.5 degrees relative to the flow control device's central longitudinal axis.

26. The method of claim 24 wherein the transition passage extends from the one end to the other end at an angle between 0.5 degrees and 30 degrees relative to the flow control device's central longitudinal axis.

27. The method of claim 24 wherein the transition passage extends from the one end to the other end smoothly.

28. The method of claim 24 wherein the first fluid-conducting passage transitions to the second fluid-conducting passage in a step change.

29. The method of claim 19 wherein the flow control device comprises a curved entry passage positioned between the inlet and the first fluid-conducting passage.

30. The method of claim 19 wherein the curved entry passage comprises a smooth surface

extending from the inlet to the first fluid-conducting passage.

31. The method of claim 19 wherein the first cross-sectional diameter is 3mm.

32. The method of claim 19 wherein the first cross-sectional diameter is in the range between 2mm and 5mm.

33. The method of claim 19 wherein the second cross-sectional diameter is 6mm.

34. The method of claim 19 wherein the first fluid-conducting passage has a length in the range between 7mm and 10mm.

35. The method of claim 19 wherein the method is used in steam assisted gravity drainage operations.

36. The method of claim 19 wherein the fluid is steam.

37. A method of producing heavy oil from an oil sands reservoir, comprising:
injecting steam into the reservoir such that heavy oil is mobilized, and a reservoir fluid mixture, including heavy oil and condensed hot water, is generated;
conducting the reservoir fluid mixture through a first fluid-conducting passage, such that the hot water of the reservoir fluid mixture is accelerated, resulting in a concomitant pressure decrease sufficient to effect vaporization of at least a fraction of the hot water, the first fluid-conducting passage having a first cross-sectional diameter and the first cross-sectional diameter being substantially constant along the first fluid-conducting passage and at least 3mm;
conducting the vaporized water through a second fluid-conducting passage and to the production conduit, the second fluid-conducting passage having a second cross-sectional diameter, the second cross-sectional diameter being substantially constant along the second fluid-conducting passage and greater than the first cross-sectional diameter at a defined ratio that is at least 3:1, and the second fluid-conducting passage having a length that is at least 20X the first cross-sectional diameter;
and recovering at least the heavy oil from the production conduit.

38. A method of producing a reservoir fluid mixture from an oil sands reservoir, comprising steps of:
- (a) receiving the reservoir fluid mixture within a flow control device;
 - (b) conducting the reservoir fluid mixture through a first fluid-conducting passage of the flow control device, such that a reservoir fluid pressure drop occurs within the reservoir fluid mixture;
 - (c) conducting the reservoir fluid mixture from the first fluid-conducting passage through to a second fluid-conducting passage of the flow control device, such that flow of the reservoir fluid mixture transitions to viscosity-dependent flow while increasing an irreversible pressure drop within a gas component of the reservoir fluid mixture within the second fluid-conducting passage; and
 - (d) conducting the reservoir fluid mixture from the second fluid-conducting passage of the flow control device to a production conduit.
39. The method of claim 38, further comprising a step of conducting the reservoir fluid mixture from the first-fluid conducting passage through a transition passage to the second fluid-conducting passage, such that an irreversible pressure drop within the reservoir fluid mixture is limited within the transition passage.
40. The method of either of claim 38 or 39, wherein the step of conducting the reservoir fluid mixture through the second fluid-conducting passage further comprises a step of decreasing an irreversible pressure drop of a liquid component of the reservoir fluid mixture within the second fluid-conducting passage.
41. The method of any one of claims 38, 39 or 40, wherein the step of conducting the reservoir fluid mixture through the first fluid-conducting passage further comprises a step of decreasing mass flow when the gas-component is present within the reservoir fluid mixture within the first fluid-conducting passage.
42. The method of any one of claims 38, 39, 40, or 41, wherein the step of conducting the reservoir fluid mixture through the first fluid-conducting passage further comprises a step of increasing mass flow when the reservoir fluid mixture comprises a liquid component.
43. The method of claim 39, wherein the step of conducting the reservoir fluid mixture from the first fluid-conducting passage through the transition passage further comprises a step of conducting the reservoir fluid mixture through the transition passage such that the irreversible pressure drop is substantially avoided by gradually increasing a cross-sectional area of the transition passage towards the second fluid-conducting passage.
44. The method of claim 39, wherein the step of conducting the reservoir fluid mixture from the first fluid-conducting passage through the transition passage further comprises a step of substantially reducing or substantially eliminating local circulation patterns within the reservoir fluid mixture.

45. The method of claim 39, wherein the step of conducting the reservoir fluid mixture from the transition passage through to the second fluid-conducting passage further comprises a step of containing one or more pressure waves within the second fluid-conducting passage.

46. The method of claim 39 or claim 45, wherein the step of conducting the reservoir fluid mixture from the transition passage through to the second fluid-conducting passage further comprises a step of reflecting one or more pressure waves within the second fluid-conducting passage.