Successive welded cylinders are sometimes slid over a perforated base pipe, welded together, and covered with a perforated shroud. Welded products require strict quality control to ensure the pore structure of the screen material is not damaged by the welding process, and that the welds themselves are of sufficient strength to withstand the significant forces encountered during deployment into long horizontal wells and during the heating and cooling cycles of steam-assisted gravity drainage (SAGD) and cyclic steam production.

SUMMARY

In accordance with a broad aspect of the present ~~invention~~disclosure, there is provided a filter medium comprising at least two layers of woven metal meshes that differ from one another in at least one of: weave pattern, weave direction, fiber size, and fiber tension.

In accordance with another broad aspect of the present ~~invention~~disclosure, there is provided a wellbore screen comprising: an apertured base pipe; an intermediate filtering layer including a filter medium wrapped around the apertured base pipe, the filter medium comprising at least two layers of woven metal meshes, the at least two layers of woven metal meshes differ from one another in at least one of: weave pattern, weave direction, fiber size, and fiber tension; and an outer apertured shell over the intermediate layer.

In accordance with another broad aspect of the present ~~invention~~disclosure, there is provided a wellbore screen comprising: an apertured base pipe; an outer apertured shell over the apertured base pipe; and filter cartridges comprising a filter medium, the filter cartridges being disposed in at least some of the apertures of one or both of the apertured base pipe and the outer apertured shell, the filter medium comprising at least two layers of woven metal meshes, the at least two layers of woven metal meshes differ from one another in at least one of: weave pattern, weave direction, fiber size, and fiber tension.

In accordance with another broad aspect of the present ~~invention~~disclosure, there is provided a method for producing a wellbore screen, the method comprising: forming a filter tube by wrapping an intermediate layer, including a filter medium strip, about an apertured

base pipe in a helical arrangement under tension, the filter medium strip comprising at least two layers of woven metal meshes, the at least two layers of woven metal meshes differ from one another in at least one of: weave pattern, weave direction, fiber size, and fiber tension; positioning the filter tube within the long bore of an outer apertured sleeve; and securing the outer apertured sleeve and the filter tube together.

In accordance with another aspect of the present disclosure, there is provided a wellbore screen comprising:

an apertured base pipe;

an intermediate filtering layer of filter medium around the apertured base pipe, the filter medium including a first helical wrap of a strip of a first woven metal mesh and a second helical wrap of a second strip of a second woven metal mesh overlapping the first helical wrap, the first woven metal mesh and the second woven metal mesh each are configured to stretch and each are formed from a weave of fibers wherein some fibers are incorporated at different tension than other fibers and wherein one of the first woven metal mesh and the second woven metal mesh has an x/y twill weave pattern, wherein x is 1 and y is greater than 2; and

an outer apertured shell over the intermediate layer.

In accordance with another aspect of the present disclosure, there is provided a method for producing a wellbore screen, the method comprising:

forming a filter tube by wrapping an intermediate layer, including a filter medium strip, about an apertured base pipe, wrapping the intermediate layer includes:

wrapping a strip of a first woven metal mesh helically under tension about the apertured base pipe to form a first layer of filter medium on the apertured base pipe; and

wrapping a strip of a second woven metal mesh helically under tension to overlap the first woven metal mesh,

the first woven metal mesh and the second woven metal mesh each are configured to stretch and each are formed from a weave of fibers wherein some fibers are incorporated at different tension than other fibers and wherein one of the first woven metal mesh and the second woven metal mesh has an *x*/*y* twill weave pattern, wherein *x* is 1 and *y* is greater than 2;

positioning the filter tube within the long bore of an outer apertured sleeve; and

securing the outer apertured sleeve and the filter tube together.

BRIEF DESCRIPTION OF THE DRAWINGS

Drawings are included for the purpose of illustrating certain aspects of the invention. Such drawings and the description thereof are intended to facilitate understanding and should not be considered limiting of the invention. Drawings are included, in which:

FIG. 1 is an elevation view of a plain weave pattern of a prior art screen material;

FIG. 2 is a simplified, partly diagrammatic plan view of an intermediate stage in one possible embodiment of the manufacturing method of the present invention;

FIG. 3 is a simplified elevation view of the apparatus of FIG. 2 with a part of that apparatus omitted to facilitate understanding;

FIG. 4 is a diagrammatic sectional elevation view taken approximately along line 4--4 in FIG. 2;

FIGS. 5a, 5b, and 5c are simplified cross-sectional views of illustrative embodiments of an interface of overlapping filter material of the wellbore screen;

FIG. 6a is a diagrammatic perspective view of a wellbore screen constructed in accordance with one embodiment of the invention with portions omitted to show the components of the screen;

FIG. 6b is a diagrammatic perspective view of a wellbore screen constructed in accordance with another embodiment of the invention with portions omitted to show the components of the screen;

I CLAIM:

1. A wellbore screen comprising:

an apertured base pipe;

an intermediate filtering layer of filter medium around the apertured base pipe, the filter medium including a first helical wrap of a strip of a first woven metal mesh and a second helical wrap of a second strip of a second woven metal mesh overlapping the first helical wrap, the first woven metal mesh and the second woven metal mesh each are configured to stretch and each are formed from a weave of fibers wherein some fibers are incorporated at different tension than other fibers and wherein one of the first woven metal mesh and the second woven metal mesh has an *x/y* twill weave pattern, wherein *x* is 1 and *y* is greater than 2; and

an outer apertured shell over the intermediate layer.

2. The wellbore screen of claim 1 wherein fibers in the first woven metal mesh and the second woven metal mesh are roughly circular or roughly triangular in cross-section and are in the range of 20 to 485 μm in thickness.

3. The wellbore screen of claim 1 wherein the filter medium has a weight between about 20 and about 180 grams per meter length of the filter medium.

4. The wellbore screen of claim 1 wherein the filter medium has a filter bed with a thickness between about 1/64" and about 3/8" and a density between about 0.1 and about 10 g/cm^3.

5. The wellbore screen of claim 1 wherein the thicknesses of the fibers in one of the first or second woven metal meshes are not uniform.

6. The wellbore screen of claim 1 wherein the filter medium has pore sizes in the range of 5 to 650 μm.

7. The wellbore screen of claim 1 wherein the *x/y* twill weave pattern is offset between rows of fibers.

8. The wellbore screen of claim 1 wherein the filter medium has an initial permeability between about 1310 and about 1950 Darcys.

9. The wellbore screen of claim 1 wherein the filter medium has an initial permeability greater than 1950 Darcys.

10. The wellbore screen of claim 1 wherein the strip is between about 1" and about 8" in width.

11. The wellbore screen of claim 1 wherein the strip has lengthwise edges, and at least a portion of the lengthwise edges overlap to form an interface.

12. The wellbore screen of claim 11 wherein the interface is bonded by at least one of: tension, welding, adhesives, fusion, clamping, pressure, and heat.

13. The wellbore screen of claim 11 wherein the lengthwise edges are shaped to mate at the interface.

14. The wellbore screen of claim 11 wherein the base pipe includes channels on its outer surface.

15. A method for producing a wellbore screen, the method comprising:

forming a filter tube by wrapping an intermediate layer, including a filter medium strip, about an apertured base pipe, wrapping the intermediate layer includes:

wrapping a strip of a first woven metal mesh helically under tension about the apertured base pipe to form a first layer of filter medium on the apertured base pipe; and

wrapping a strip of a second woven metal mesh helically under tension to overlap the first woven metal mesh,

the first woven metal mesh and the second woven metal mesh each are configured to stretch and each are formed from a weave of fibers wherein some fibers are incorporated at different tension than other fibers and wherein one of the first woven metal mesh and the second woven metal mesh has an *x/y* twill weave pattern, wherein *x* is 1 and *y* is greater than 2;

positioning the filter tube within the long bore of an outer apertured sleeve; and

securing the outer apertured sleeve and the filter tube together.

16. The method of claim 15 wherein wrapping includes securing a starting end of the strip of the first woven metal mesh to the apertured base pipe; rotating the apertured base pipe about its axis; and applying a pulling tension to the strip of the first woven metal mesh to draw the strip of the first woven metal mesh in a helical orientation onto the apertured base pipe.

17. The method of claim 16 wherein the pulling tension is between about 10 lbsf and about 5000 lbsf.

18. The method of claim 16 wherein the strip of the first woven metal mesh is carried on a supply roll and the pulling tension is applied by a brake in the supply roll.

19. The method of claim 16 wherein the strip of the first woven metal mesh is carried on a supply roll and the pulling tension is applied by clamping the strip of the first woven metal mesh after the strip of the first woven metal mesh rolls out of the supply roll.

20. The method of claim 15 wherein fibers in the first woven metal mesh and the second woven metal mesh are roughly circular or roughly triangular in cross-section and are in the range of 20 to 485 μm in thickness.

21. The method of claim 15 wherein the strip of the first woven metal mesh has a weight between about 20 and about 180 grams per meter length of the strip of the first woven metal mesh.

22. The method of claim 15 wherein the strip of the first woven metal mesh has a filter bed with a thickness between about 1/64" and about 3/8" and a density between about 0.1 and about 10 g/cm^3.

23. The method of claim 15 wherein the thicknesses of the fibers in one of the first woven metal mesh and the second woven metal mesh are not uniform.

24. The method of claim 15 wherein the *x/y* twill weave pattern is offset between rows of fibers.

25. The method of claim 15 wherein the strip of the first woven metal mesh has pore sizes in the range of 5 to 650 μm.

26. The method of claim 15 wherein the strip of the first woven metal mesh has an initial permeability between about 1310 and about 1950 Darcys.

27. The method of claim 15 wherein the strip of the first woven metal mesh has an initial permeability greater than 1950 Darcys.

28. The method of claim 15 wherein the strip is between about 1" and about 8" in width.

29. The method of claim 15 wherein the strip of the first woven metal mesh has lengthwise edges, and the method further comprising overlapping at least a portion of the lengthwise edges of each helical wrap over a previously laid down helical wrap to form an interface.

30. The method of claim 29 further comprising bonding the interface by at least one of: tension, welding, adhesives, fusion, clamping, pressure, and heat.

31. The method of claim 29 wherein the lengthwise edges are shaped to mate at the interface.

32. The method of claims 18 or 19 wherein the supply roll rides along an axis parallel to the apertured base pipe.

I CLAIM:

1. A filter medium comprising at least two layers of woven metal meshes that differ from one another in at least one of: weave pattern, weave direction, fiber size, and fiber tension.

2. The filter medium of claim 1 wherein fibers in the at least two layers of woven metal meshes are roughly circular or roughly triangular in cross-section and are in the range of 20 to 485 μm in thickness.

3. The filter medium of claim 1 having a weight between about 20 and about 180 grams per meter length of the filter medium.

4. The filter medium of claim 1 having a filter bed with a thickness between about 1/64" and about 3/8" and a density between about 0.1 and about 10 g/cm^3.

5. The filter medium of claim 1 wherein the thicknesses of the fibers in one of the at least two layers of woven metal meshes are not uniform.

6. The filter medium of claim 1 wherein one of the at least two layers of woven metal meshes has an *x/y* twill weave pattern, wherein *x* is 1 and *y* is greater than 2.

7. The filter medium of claim 1 having pore sizes in the range of 5 to 650 μm.

8. The filter medium of claim 1 having an initial permeability between about 1310 and about 1950 Darcys.

9. The filter medium of claim 1 having an initial permeability greater than 1950 Darcys.

10. A wellbore screen comprising:

an apertured base pipe;

an intermediate filtering layer including a filter medium wrapped around the apertured base pipe, the filter medium comprising at least two layers of woven metal meshes, the at least two layers of woven metal meshes differ from one

another in at least one of: weave pattern, weave direction, fiber size, and fiber tension; and

an outer apertured shell over the intermediate layer.

11. The wellbore screen of claim 10 wherein fibers in the at least two layers of woven metal meshes are roughly circular or roughly triangular in cross-section and are in the range of 20 to 485 μm in thickness.

12. The wellbore screen of claim 10 wherein the filter medium has a weight between about 20 and about 180 grams per meter length of the filter medium.

13. The wellbore screen of claim 10 wherein the filter medium has a filter bed with a thickness between about 1/64" and about 3/8" and a density between about 0.1 and about 10 g/cm^3.

14. The wellbore screen of claim 10 wherein the thicknesses of the fibers in one of the at least two layers of woven metal meshes are not uniform.

15. The wellbore screen of claim 10 wherein one of the at least two layers of woven metal meshes has an *x*/*y* twill weave pattern, wherein *x* is 1 and *y* is greater than 2.

16. The wellbore screen of claim 10 wherein the filter medium has pore sizes in the range of 5 to 650 μm.

17. The wellbore screen of claim 10 wherein the filter medium has an initial permeability between about 1310 and about 1950 Darcys.

18. The wellbore screen of claim 10 wherein the filter medium has an initial permeability greater than 1950 Darcys.

19. The wellbore screen of claim 10 wherein the filter medium is a strip that is wrapped helically about the apertured base pipe.

20. The wellbore screen of claim 19 wherein the strip is between about 1" and about 8" in width.

21. The wellbore screen of claim 19 wherein the strip has lengthwise edges, and at least a portion of the lengthwise edges overlap to form an interface.

22. The wellbore screen of claim 21 wherein the interface is bonded by at least one of: tension, welding, adhesives, fusion, clamping, pressure, and heat.

23. The wellbore screen of claim 21 wherein the lengthwise edges are shaped to mate at the interface.

24. The wellbore screen of claim 21 wherein the base pipe includes channels on its outer surface.

25. A wellbore screen comprising:

an apertured base pipe;

an outer apertured shell over the apertured base pipe; and

filter cartridges comprising a filter medium, the filter cartridges being disposed in at least some of the apertures of one or both of the apertured base pipe and the outer apertured shell, the filter medium comprising at least two layers of woven metal meshes, the at least two layers of woven metal meshes differ from one another in at least one of: weave pattern, weave direction, fiber size, and fiber tension.

26. The wellbore screen of claim 25 wherein fibers in the at least two layers of woven metal meshes are roughly circular or roughly triangular in cross-section and are in the range of 20 to 485 μm in thickness.

27. The wellbore screen of claim 25 wherein the filter medium has a weight between about 20 and about 180 grams per meter length of the filter medium.

28. The wellbore screen of claim 25 wherein the filter medium has a filter bed with a thickness between about 1/64" and about 3/8" and a density between about 0.1 and about 10 g/cm^3.

29. The wellbore screen of claim 25 wherein the thicknesses of the fibers in one of the at least two layers of woven metal meshes are not uniform.

30. The wellbore screen of claim 25 wherein one of the at least two layers of woven metal meshes has an *x/y* twill weave pattern, wherein *x* is 1 and *y* is greater than 2.

31. The wellbore screen of claim 25 wherein the filter medium has pore sizes in the range of 5 to 650 µm.

32. The wellbore screen of claim 25 wherein the filter medium has an initial permeability between about 1310 and about 1950 Darcys.

33. The wellbore screen of claim 25 wherein the filter medium has an initial permeability greater than 1950 Darcys.

34. A method for producing a wellbore screen, the method comprising:

forming a filter tube by wrapping an intermediate layer, including a filter medium strip, about an apertured base pipe in a helical arrangement under tension, the filter medium strip comprising at least two layers of woven metal meshes, the at least two layers of woven metal meshes differ from one another in at least one of: weave pattern, weave direction, fiber size, and fiber tension;

positioning the filter tube within the long bore of an outer apertured sleeve; and

securing the outer apertured sleeve and the filter tube together.

35. The method of claim 34 wherein wrapping includes securing a starting end of the filter medium strip to the apertured base pipe; rotating the apertured base pipe about its axis; and applying a pulling tension to the filter medium strip to draw the filter medium strip in a helical orientation on to the apertured base pipe.

36. The method of claim 35 wherein the pulling tension is between about 10 lbsf and about 5000 lbsf.

37. The method of claim 35 wherein the filter medium strip is carried on a supply roll and the pulling tension is applied by a brake in the supply roll.

38. The method of claim 35 wherein the filter medium strip is carried on a supply roll and the pulling tension is applied by clamping the filter medium strip after the filter medium strip rolls out of the supply roll.

39. The method of claim 34 wherein fibers in the at least two layers of woven metal meshes are roughly circular or roughly triangular in cross-section and are in the range of 20 to 485 μm in thickness.

40. The method of claim 34 wherein the filter medium strip has a weight between about 20 and about 180 grams per meter length of the filter medium strip.

41. The method of claim 34 wherein the filter medium strip has a filter bed with a thickness between about 1/64" and about 3/8" and a density between about 0.1 and about 10 g/cm^3.

42. The method of claim 34 wherein the thicknesses of the fibers in one of the at least two layers of woven metal meshes are not uniform.

43. The method of claim 34 wherein one of the at least two layers of woven metal meshes has an *x*/*y* twill weave pattern, wherein *x* is 1 and *y* is greater than 2.

44. The method of claim 34 wherein the filter medium strip has pore sizes in the range of 5 to 650 μm.

45. The method of claim 34 wherein the filter medium strip has an initial permeability between about 1310 and about 1950 Darcys.

46. The method of claim 34 wherein the filter medium strip has an initial permeability greater than 1950 Darcys.

47. The method of claim 34 wherein the filter medium strip is between about 1" and about 8" in width.

48. The method of claim 34 wherein the filter medium has lengthwise edges, and the method further comprising overlapping at least a portion of the lengthwise edges to form an interface.

49. The method of claim 48 further comprising bonding the interface by at least one of: tension, welding, adhesives, fusion, clamping, pressure, and heat.

50. The method of claim 48 wherein the lengthwise edges are shaped to mate at the interface.

51. The method of claim 37 wherein the supply roll rides along an axis parallel to the apertured base pipe.