

SCREEN ASSEMBLY AND METHODS OF USE

BACKGROUND

[0001] Embodiments described herein generally relate to downhole tools. More particularly, such embodiments relate to a screen assembly for use during gravel packing in a wellbore.

[0002] Hydrocarbons produced from a subterranean formation oftentimes have sand or other particulates dispersed therein. As the sand is undesirable to produce, many techniques exist for reducing the sand content in the hydrocarbons. Gravel packing is one technique used to filter and separate the sand from the hydrocarbons in a subterranean formation.

[0003] Gravel packing generally involves running a base pipe into the wellbore. A screen is wrapped around the section of the base pipe positioned adjacent to the hydrocarbon-producing formation. A gravel slurry, including gravel particulates dispersed within a carrier fluid, is pumped down a work string and into the annulus formed between the screen and the wall of the wellbore. The carrier fluid flows through the screen and back up to the surface while the gravel particulates remain disposed in the annulus between the screen and the wall of the wellbore. The gravel particulates are used to filter and separate the sand from the hydrocarbons as the hydrocarbons are being produced from the formation.

[0004] In horizontal or deviated wellbores, voids tend to form in the gravel particulates between the screen and the wall of the wellbore. The void presents a path of lesser resistance for the hydrocarbons and the sand to flow through the screen and into the base pipe, resulting in sand being produced to the surface and the screen being more exposed to damage from, for example, erosion. What is needed is an improved system and method for gravel packing an annulus between a screen and wall of a wellbore.

SUMMARY

[0005] This summary is provided to introduce a selection of concepts that are further described below in the detailed description. This summary is not intended to identify key or essential features of the claimed subject matter, nor is it intended to be used as an aid in limiting the scope of the claimed subject matter.

[0006] An illustrative screen assembly is provided. The screen assembly may include a base pipe having an axial bore formed therethrough. An axial rod may be positioned radially-outward from the base pipe. A screen may be positioned radially-outward from the axial rod. A housing may be positioned radially-outward from the base pipe and axially adjacent to the axial rod, the screen, or both, and a first annulus may be formed between the housing and the base pipe. A first opening may be formed through the base pipe and radially-inward from the housing. A second opening may be formed through the base pipe and radially-inward from the housing, and the second opening may be axially offset from the first opening. A valve may be disposed within the first annulus and positioned axially between the first and second openings. The valve may allow a fluid to flow axially therethrough when in an open position and prevent the fluid from flowing axially therethrough when in a closed position.

[0007] Another illustrative screen assembly is also provided. The screen assembly may include a base pipe having an axial bore formed therethrough. An axial rod may be positioned radially-outward from the base pipe. A screen may be positioned radially-outward from the axial rod. First and second axial channels may be formed between the screen and the base pipe. The axial rod may be positioned between the first and second axial channels. An opening may be formed through the axial rod, between the axial rod and the base pipe, or both, and the opening provides a path of fluid communication between the first and second axial channels. A housing may be positioned radially-outward from the base pipe and axially adjacent to the axial rod, the screen, or both, and an annulus may be formed between the housing and the base pipe. A radial opening may be formed through the base pipe and radially-inward from the housing. An inflow control device may be formed in the base pipe and radially-inward from the housing, and the inflow control device may be axially offset from the radial opening. A valve may be disposed within the annulus and positioned axially between the radial opening and the inflow control device. The valve may allow a fluid to flow axially therethrough when in an open position and prevent the fluid from flowing axially therethrough when in a closed position.

[0008] A method of gravel packing an annulus between a screen and a wall of a wellbore is also provided. The method may include flowing a gravel slurry into the annulus between the screen and the wall of the wellbore. The gravel slurry may include a plurality of gravel particulates and a carrier fluid. The carrier fluid may flow through the screen and into a first axial channel formed between the screen and a base pipe positioned radially-inward

therefrom. The first axial channel may be circumferentially offset from a second axial channel, and an axial rod may be positioned between the first and second axial channels. A portion of the carrier fluid may flow from the first axial channel to the second axial channel through an opening formed through the axial rod, between the axial rod and the base pipe, or both. The portion of the carrier fluid may flow through the second axial channel and into an annulus formed between a housing and the base pipe. The housing may be axially offset from the axial rod, the screen, or both. The portion of the carrier fluid may flow axially through a valve disposed within the annulus formed between the housing and the base pipe. The portion of the carrier fluid may flow through a first radial opening formed in the base pipe and into an axial bore formed through the base pipe.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] So that the recited features may be understood in detail, a more particular description, briefly summarized above, may be had by reference to one or more embodiments, some of which are illustrated in the appended drawings. It is to be noted, however, that the appended drawings are only illustrative embodiments, and are, therefore, not to be considered limiting of its scope.

[0010] Figure 1 depicts a cross-sectional view of an illustrative screen assembly, according to one or more embodiments disclosed.

[0011] Figure 2 depicts a cross-sectional view of the screen assembly taken along the lines 2-2 in Figure 1, according to one or more embodiments disclosed.

[0012] Figure 3 depicts a cross-sectional view of another illustrative screen assembly, according to one or more embodiments disclosed.

[0013] Figure 4 depicts a cross-sectional view of the screen assembly taken along the lines 4-4 in Figure 3, according to one or more embodiments disclosed.

[0014] Figure 5 depicts a cross-sectional view of another illustrative screen assembly, according to one or more embodiments disclosed.

[0015] Figure 6 depicts a cross-sectional view of the screen assembly taken along the lines 6-6 in Figure 5, according to one or more embodiments disclosed.

[0016] Figure 7 depicts a cross-sectional view of another illustrative screen assembly, according to one or more embodiments disclosed.

[0017] Figure 8 depicts a cross-sectional view of the screen assembly taken along the lines 8-8 in Figure 7, according to one or more embodiments disclosed.

[0018] Figure 9 depicts a cross-sectional view of another illustrative screen assembly, according to one or more embodiments disclosed.

[0019] Figure 10 depicts a cross-sectional view of the screen assembly taken along the lines 10-10 in Figure 9, according to one or more embodiments disclosed.

[0020] Figure 11 depicts a cross-sectional view of another illustrative screen assembly, according to one or more embodiments disclosed.

DETAILED DESCRIPTION

[0021] Figure 1 depicts a cross-sectional view of an illustrative screen assembly 100, and Figure 2 depicts a cross-sectional view of the screen assembly 100 taken along the lines 2-2 in Figure 1, according to one or more embodiments. The screen assembly 100 may include a base pipe 110, a plurality of axial rods 121-128, and a screen 150.

[0022] The base pipe 110 may be a tubular body having a first end 111, a second end 112, and an axial bore 113 formed therethrough. The base pipe 110 may be adapted to be placed in a wellbore 102. For example, the base pipe 110 may be adapted to be placed in a horizontal or deviated wellbore 102 having a heel and a toe. As used herein, a "deviated wellbore" has a longitudinal axis that is oriented at an angle less than about 45° with respect to horizontal. The first end 111 of the base pipe 110 may be positioned proximate the heel of the wellbore 102, and the second end 112 of the base pipe 110 may be positioned proximate the toe of the wellbore 102.

[0023] The base pipe 110 may have one or more perforations or openings ("first openings") 114, 115, 116 formed radially therethrough. The openings 114, 115, 116 may be axially and/or circumferentially offset around the base pipe 110. The base pipe 110 may also have one or more perforations or openings ("second openings") 117 formed radially therethrough and axially offset from the first openings 114, 115, 116. As shown, the second opening 117 is positioned between the openings 114, 115, 116 and the first end 111 of the base pipe 110. The second opening 117 may include an inflow control device disposed therein or integral

therewith. The inflow control device may be or include a nozzle or other flow-restricting device. The inflow control device may facilitate substantially uniform fluid flow into the bore 113 of the base pipe 110 from the wellbore 102. Although not shown, one or more additional inflow control devices may be axially offset along the base pipe 110.

[0024] The first openings 114, 115, 116 and the second opening 117 may both be adapted to have fluid flow therethrough. The first openings 114, 115, 116 (in the aggregate), however, may have a larger cross-sectional area for fluid to flow therethrough than the second openings 117. For example, a ratio of the cross-sectional area of the first openings 114, 115, 116 to the cross-sectional area of the second openings 117 may be greater than about 4:1, about 6:1, about 8:1, about 10:1, about 15:1, about 20:1, about 50:1, or more. As a result, a greater volume of fluid may flow into the bore 113 of the base pipe 110 through the first openings 114, 115, 116 than through the second opening 117.

[0025] The rods 121-128 may be disposed radially-outward from the base pipe 110 and extend axially along the outer surface thereof. In at least one embodiment, the rods 121-128 may not extend over the second opening 117. For example, the second opening 117 may be positioned axially between an end 129 of the rods 121-128 and the first openings 114, 115, 116 in the base pipe 110.

[0026] The rods 121-128 may be circumferentially offset from one another around the base pipe 110. An axial channel 131 may be formed between two adjacent rods 121, 122. Accordingly, a plurality of axial channels 131-138 may be circumferentially offset from one another around the base pipe 110. Although eight rods 121-128 and eight channels 131-138 are shown, it may be appreciated that the number of rods 121-128 and channels 131-138 may range from a low of about 4, 6, 8, or 10 to a high of about 15, 20, 30, 40, or more.

[0027] The rods 121-128 may be solid and have a cross-sectional shape that is triangular (as shown), circular, rectangular, trapezoidal, or the like. The height 142 of the rods 121-128 and/or the channels 131-138 may range from a low of about 1 mm, about 2 mm, about 4 mm, or about 6 mm to a high of about 10 mm, about 15 mm, about 20 mm, about 25 mm, or more. For example, the height 142 of the rods 121-128 and/or the channels 131-138 may be between about 8 mm and about 15 mm, about 15 mm and about 22 mm, or between 10 mm and about 20 mm.

[0028] The rods 121-128 may have one or more perforations or openings ("third openings") 140 formed therethrough to form a path of fluid communication between the channels 131-

138. As shown, each rod 121-128 has six axially-offset circular openings 140 formed therethrough; however, as may be appreciated the number, size, shape, and orientation of the openings 140 in the rods 121-128 may be varied. A longitudinal axis through the openings 140 may be substantially perpendicular to a longitudinal axis through the rods 121-128. As a result, fluid may flow between the channels 131-138 through the openings 140. For example, fluid in a first channel 131 may flow through the opening 140 in rod 122 and into a second channel 132, or *vice versa*. The openings 140 may enable the flow rate and/or pressure of the fluid in each channel 131-138 to be the same or substantially the same.

[0029] The screen 150 may be positioned radially-outward from the rods 121-128. In at least one embodiment, the screen 150 may be or include a wire that is wrapped helically around the rods 121-128 on the base pipe 110. A gap may be formed between each axially offset wrap of the wire. As used herein, each "wrap" of the wire is 360° around the rods 121-128 and the base pipe 110. The gap may range from a low of about 0.1 mm, about 0.2 mm, about 0.3, about 0.4 mm, or about 0.5 mm to a high of about 0.6 mm, about 0.8 mm, about 1 mm, about 2 mm, about 5 mm, or more. In another embodiment, the screen 150 may be an annular shroud or sleeve having radial perforations or openings formed therethrough. For example, the screen 150 may be made of a mesh material.

[0030] A first annular housing 160 may be disposed radially outward from the base pipe 110 and axially adjacent to the rods 121-128 and/or the screen 150. The first housing 160 may be disposed axially between the rods 121-128 and the second end 112 of the base pipe 110. A first annulus 162 may be formed between the first housing 160 and the base pipe 110. The first annulus 162 may provide a flow path around the circumference of the base pipe 110. The first annulus 162 may be in fluid communication with each of the channels 131-138.

[0031] One or more valves (one is shown 164) may be disposed in the annulus 162 between the base pipe 110 and the first housing 160. The valve 164 may be positioned axially between the first openings 114, 115, 116 and the second opening 117 in the base pipe 110. When the valve 164 is in a first or "open" position (as shown), fluid may flow axially therethrough. When the valve 164 is in a second or "closed" position (not shown), fluid flow therethrough may be obstructed. In at least one embodiment, a packer may be used instead of, or in addition to, the valve 164.

[0032] Figure 3 depicts a cross-sectional view of another illustrative screen assembly 200, and Figure 4 depicts a cross-sectional view of the screen assembly 200 taken along the lines

4-4 in Figure 3, according to one or more embodiments. The height of the rods 221-228 may vary along the axial length of the rods 221-228 to form gaps or openings 240 between the inner surface of the rods 221-228 and the outer surface of the base pipe 110. More particularly, the height of the rods 221-228 may vary along the axial length of the rods 221-228 from a first height 242, at which the inner surface of the rods 221-228 are in contact with the outer surface of the base pipe 110, to a second height 244, at which the inner surface of the rods 221-228 are spaced apart from the base pipe 110, thereby forming the openings 240.

[0033] The openings 240 may provide a path of fluid communication between the channels 131-138. For example, fluid in the first channel 131 may flow through the opening 240 "under" a first rod 222 and into the second channel 132, or *vice versa*. The openings 240 may enable the flow rate and/or pressure of the fluid in each channel 131-138 to be the same or substantially the same.

[0034] Figure 5 depicts a cross-sectional view of another illustrative screen assembly 300, and Figure 6 depicts a cross-sectional view of the screen assembly 300 taken along the lines 6-6 in Figure 5, according to one or more embodiments. An annular drainage layer 340 may be disposed between the base pipe 110 and the rods 321-328. Although not shown, in another embodiment, the drainage layer 340 may be disposed between the rods 110 and the screen 150. The drainage layer 340 may include a material that allows fluid to flow therethrough. For example, the material in the drainage layer 340 may include mesh, compressed wool, or the like.

[0035] The drainage layer 340 may provide a path of fluid communication between the channels 131-138. For example, fluid in the first channel 131 may flow through the drainage layer 340 "under" a first rod 322 and into the second channel 132, or *vice versa*. The drainage layer 340 may enable the flow rate and/or pressure of the fluid in each channel 131-138 to be the same or substantially the same.

[0036] Figure 7 depicts a cross-sectional view of another illustrative screen assembly 400, and Figure 8 depicts a cross-sectional view of the screen assembly 400 taken along the lines 8-8 in Figure 7, according to one or more embodiments disclosed. One or more openings 440 may be formed between the rods 421-428 and the base pipe 110. As shown, the openings 440 may be grooves (*i.e.*, an area of reduced outer diameter) formed in the outer surface of the base pipe 110.

[0037] The openings 440 may be axially offset along the base pipe 110. The openings 440 may extend partially around the circumference of the base pipe 110, or the openings 440 may extend completely around the circumference of the base pipe 110, thereby forming annular grooves between the outer surface of the base pipe 110 and the rods 421-428. In another embodiment, the openings 440 may be helical groove(s) in the outer surface of the base pipe 110.

[0038] The openings 440 may provide a path of fluid communication between the channels 131-138. For example, fluid in the first channel 131 may flow through the opening 440 "under" a first rod 422 and into the second channel 132, or *vice versa*. The openings 440 may enable the flow rate and/or pressure of the fluid in each channel 131-138 to be the same or substantially the same.

[0039] Figure 9 depicts a cross-sectional view of another illustrative screen assembly 500, and Figure 10 depicts a cross-sectional view of the screen assembly 500 taken along the lines 10-10 in Figure 8, according to one or more embodiments. A second annular housing 570 may be disposed radially outward from the base pipe 110 and adjacent to the rods 521-528 and the screen 150. The second housing 570 may be disposed axially between the first end 111 of the base pipe 110 and the rods 521-528. A second annulus 572 may be formed between the second housing 570 and the base pipe 110. The second annulus 572 between the second housing 570 and the base pipe 110 may be in communication with the first annulus 162 between the first housing 160 and the base pipe 110 via the channels (not shown).

[0040] The second annulus 572 may provide a path of fluid communication around the circumference of the base pipe 110. For example, fluid in the first channel may flow into the second annulus 572 and into the second channel. The second annulus 572 may enable the flow rate and/or pressure of the fluid in each channel to be the same or substantially the same.

[0041] Figure 11 depicts a cross-sectional view of another illustrative screen assembly 600, according to one or more embodiments. The screen assembly 600 may include a plurality of sets of rods (three sets are shown 621, 622, 623). The sets of rods 621, 622, 623 may extend axially along the outer surface of the base pipe 110. The first set of rods 621 may be axially offset from the second set of rods 622, and the second set of rods 622 may be axially offset from the third set of rods 623. The three sets of rods 621, 622, 623 may be positioned axially between the first end of the base pipe 111 and the second opening 117.

[0042] Annular housings 670, 680, 690 may be disposed radially outward from the base pipe 110 and between each set of rods 621, 622, 623. As shown, a second housing 670 may be disposed axially between the first end 111 of the base pipe 110 and the first set of rods 621, a third housing 680 may be disposed axially between the first set of rods 621 and the second set of rods 622, and a fourth housing 690 may be disposed axially between the second set of rods 622 and the third set of rods 623. Although three sets of rods 621, 622, 623 and three housings 670, 680, 690 are shown, it may be appreciated that any number of sets of rods 621, 622, 623 and/or housings 670, 680, 690 may be used.

[0043] An annulus 672, 682, 692 may be formed between each housing 670, 680, 690 and the base pipe 110. The second annulus 672 formed by the second housing 670 may be in fluid communication with the third annulus 682 formed by the third housing 680 through the channels (not shown) formed between the first set of rods 621. The third annulus 682 may be in fluid communication with the fourth annulus 392 formed by the fourth housing 690 through the channels (not shown) formed between the second set of rods 622. The fourth annulus 692 may be in fluid communication with the first annulus 162 through the channels (not shown) formed between the third set of rods 623.

[0044] Now referring to Figures 1-11, in operation, the first end 111 of the base pipe 110 may be coupled to the lower end of a work string (not shown), and the work string may run the base pipe 110 into the wellbore 102. The base pipe 110 may be positioned in a horizontal or deviated section of the wellbore 102, as shown. A gravel slurry may be pumped down the work string from the surface. The gravel slurry may include gravel or other particulates dispersed within a carrier fluid. The gravel slurry may flow out of the work string and into an annulus formed between the work string and the wall of the wellbore 102.

[0045] The gravel slurry may then flow downstream into the annulus 104 formed between the screen 150 and the wall of the wellbore 102 in a direction (shown by arrow 170) toward the second end 112 of the base pipe 110. As the gravel slurry flows in the direction 170, a portion of the gravel therein may be deposited or packed in a lower portion of the annulus 104. As used herein, the lower portion of the annulus 104 may refer to the portion of the annulus 104 adjacent channels 134, 135 (*i.e.*, between about 135° and about 225°), the portion of the annulus 104 adjacent channels 133-136 (*i.e.*, between about 90° and about 270°), or the portion of the annulus 104 adjacent channels 132-137 (*i.e.*, between about 45° and about 315°). In another embodiment, the lower portion of the annulus 104 may include

covering the circumference of the screen 150, leaving a gap between the gravel and the wall of the wellbore 102. Channels 133-136 are used going forward as illustrative channels disposed adjacent to the lower portion of the annulus 104.

[0046] The gravel that is deposited in the lower portion of the annulus 104 is referred to as the alpha wave. The alpha wave may propagate in the lower portion of the annulus 104 in the direction 170. In other words, the lower portion of the annulus 104 may be gradually filled with gravel in the direction 170, *i.e.*, the same direction 170 that the gravel slurry flows. As the alpha wave is deposited in the lower portion of the annulus 104, it may block the lower portion of the annulus 104 so the gravel slurry may not flow therethrough. With the lower portion of the annulus 104 blocked, the gravel slurry may flow in the direction 170 in an upper portion of the annulus 104. As used herein, the upper portion of the annulus 104 refers to the portion of the annulus that is not filled with the alpha wave. For example the upper portion of the annulus 104 may refer to the portion of the annulus 104 adjacent channels 131, 138 (*i.e.*, between about 315° and about 45°), the portion of the annulus 104 adjacent channels 131, 132, 137, 138 (*i.e.*, between about 270° and about 90°), or the portion of the annulus 104 adjacent channels 131, 132, 133, 136, 137, 138 (*i.e.*, between about 225° and about 135°). Channels 131, 132, 137, 138 are used going forward as illustrative channels disposed adjacent to the upper portion of the annulus 104.

[0047] The flow rate of the gravel slurry may determine the rate at which the alpha wave accumulates in the annulus 104. For example, when the gravel slurry has a "high" flow rate, the gravel may remain suspended in the gravel slurry and, as such, the alpha wave may not accumulate in the lower portion of the annulus 104. When the gravel slurry has a "medium" flow rate, a portion of the gravel may separate from the gravel slurry and form the alpha wave in the lower portion of the annulus 104. The alpha wave may block the lower portion of the annulus 104 causing the gravel slurry to flow through the upper portion of the annulus 104. When the gravel slurry has a "low" flow rate, the gravel may become deposited in the upper and lower portions of the annulus 104, preventing further flow through the annulus 104. Thus, the flow rate of the gravel slurry may determine the amount or portion of the annulus 104 in which the alpha wave accumulates.

[0048] As the alpha wave propagates through the lower portion of the annulus 104, at least a portion of the carrier fluid in the gravel slurry may flow through the screen 150 and into one or more of the channels 131-138 between the screen 150 and the base pipe 110, as shown by

arrow 172. The screen 150 may prevent the gravel in the gravel slurry from flowing therethrough and into the channels 131-138. The carrier fluid may flow through the screen 150 and into the channels (*e.g.*, 133-136) disposed adjacent to the lower portion of the annulus 104.

[0049] The carrier fluid may flow through the channels 131-138 and into the annulus 162 formed between the first housing 160 and the base pipe 110, as shown by arrow 174. A first portion of the carrier fluid may flow through the second opening 117 and into the bore 113 in the base pipe 110, as shown by arrow 176. A second portion of the carrier fluid may flow through the valve 164 and into the bore 113 of the base pipe 110 through the openings 114, 115, 116, as shown by arrow 178. When in the bore 113, the carrier fluid may continue to flow toward the second end 112 of the base pipe 110 through an annulus between the base pipe 110 and a wash pipe (not shown) disposed therein. When the carrier fluid reaches the end of the wash pipe, the carrier fluid may flow into the wash pipe and back toward the surface (*i.e.*, toward the first end 111 of the base pipe 110).

[0050] Referring back to the annulus 104 between the screen 150 and the wall of the wellbore 102, after the alpha wave is deposited in the lower portion of the annulus 104 around the screen 150 and any additional screens downstream therefrom (not shown), the gravel may begin to deposit in the upper portion of the annulus 104. The gravel that is deposited in the upper portion of the annulus 104 is referred to as the beta wave. The beta wave may propagate in the upper portion of the annulus 104 in the direction 180. In other words, the upper portion of the annulus 104 may be gradually filled with gravel in the direction 180, *i.e.*, the opposite direction that the gravel slurry is flowing.

[0051] When the alpha wave covers the screen 150 in the lower portion of the annulus 104 and the beta wave covers some or most of the screen 150 in the upper portion of the annulus 104, a portion of the carrier fluid in the gravel slurry may flow through the screen 150 and into the channels (*e.g.*, 131, 132, 137, 138) disposed adjacent to the upper portion of the annulus 104. The fluid in the channels (*e.g.*, 131, 132, 137, 138) disposed adjacent to the upper portion of the annulus 104 may flow into the channels (*e.g.*, 133-136) adjacent to the lower portion of the annulus 104.

[0052] In at least one embodiment, the carrier fluid may flow from the channels (*e.g.*, 131, 132, 137, 138) adjacent to the upper portion of the annulus 104 into the channels (*e.g.*, 133-136) adjacent to the lower portion of the annulus 104 through the openings 140 formed

through the rods 121-128, as shown in Figures 1 and 2. In another embodiment, the carrier fluid may flow from the channels (*e.g.*, 131, 132, 137, 138) adjacent to the upper portion of the annulus 104 into the channels (*e.g.*, 133-136) adjacent to the lower portion of the annulus 104 through the openings 240 formed between the variable inner surface of the rods 221-228 and the outer surface of the base pipe 110, as shown in Figures 3 and 4. In yet another embodiment, the carrier fluid may flow from the channels (*e.g.*, 131, 132, 137, 138) adjacent to the upper portion of the annulus 104 into the channels (*e.g.*, 133-136) adjacent to the lower portion of the annulus 104 through the openings in the drainage layer 340 disposed between the rods 321-328 and the base pipe 110, as shown in Figures 5 and 6. In yet another embodiment, the carrier fluid may flow from the channels (*e.g.*, 131, 132, 137, 138) adjacent to the upper portion of the annulus 104 into the channels (*e.g.*, 133-136) adjacent to the lower portion of the annulus 104 through grooves 440 formed into the outer surface of the base pipe 110, as shown in Figures 7 and 8. In yet another embodiment, the carrier fluid may flow from the channels (*e.g.*, 131, 132, 137, 138) adjacent to the upper portion of the annulus 104 into the channels (*e.g.*, 133-136) adjacent to the lower portion of the annulus 104 through the second housing 570 disposed between the first end 111 of the base pipe 110 and the rods 521-528, as shown in Figures 9 and 10.

[0053] Distributing the carrier fluid between the channels 131-138 may reduce the flow rate of the carrier fluid through the channels 131-138. Reducing the flow rate may reduce the pressure loss as the carrier fluid flows through the channels 131-138 (*e.g.*, approximately 5-10 meters). In addition, increasing the height of the axial rods (*e.g.*, 121-128) to between about 8 mm and about 22 mm may increase the cross-sectional area of the channels 131-138. This may further decrease the average velocity of the carrier fluid through the channels 131-138 and, as a result, decrease the pressure loss.

[0054] The carrier fluid may flow through the channels 131-138 and into the annulus 162 formed between the first housing 160 and the base pipe 110, as shown by arrow 184. A first portion of the carrier fluid may flow through the second opening 117 and into the bore 113 in the base pipe 110, as shown by arrow 186. A second portion of the carrier fluid may flow through the valve 164 and into the bore 113 of the base pipe 110 through the openings 114, 115, 116, as shown by arrow 188. When in the bore 113, the carrier fluid may continue to flow toward the second end 112 of the base pipe 110 through the annulus between the base pipe 110 and the wash pipe (not shown) disposed therein. When the carrier fluid reaches the

end of the wash pipe, the carrier fluid may flow into the wash pipe and back toward the surface (*i.e.*, toward the first end 111 of the base pipe 110). The wash pipe is removed from the wellbore 102 when gravel packing is complete.

[0055] Once the upper and lower portions of the annulus 104 between the screen 150 and the wall of the wellbore 102 are packed by the alpha and beta waves, respectively, the valve 164 may be closed to prevent fluid from flowing axially therethrough. The wellbore 102 may then begin producing hydrocarbons from the subterranean formation. The dehydrated gravel that is packed in the annulus 104 between the screen 150 and the wall of the wellbore 102 may filter at least a portion of the sand or other particulates dispersed within the hydrocarbons. The filtered hydrocarbons may then flow through the screen 150 and into the channels 131-138. The flow rate and/or pressure of the filtered hydrocarbons may be reduced by flowing the hydrocarbons between the channels 131-138 (as described above with reference to the carrier fluid). As the valve 164 is closed, the filtered hydrocarbons may flow into the bore 113 of the base pipe 110 through the second opening 117. The filtered hydrocarbons may then flow to the surface via the bore.

[0056] As used herein, the terms "inner" and "outer"; "up" and "down"; "upper" and "lower"; "upward" and "downward"; "above" and "below"; "inward" and "outward"; "high," "medium," and "low"; and other like terms as used herein refer to relative positions or rates to one another and are not intended to denote a particular direction or spatial orientation. The terms "couple," "coupled," "connect," "connection," "connected," "in connection with," and "connecting" refer to "in direct connection with" or "in connection with via another element or member." The terms "hot" and "cold" refer to relative temperatures to one another.

[0057] Although only a few example embodiments have been described in detail above, those skilled in the art will readily appreciate that many modifications are possible in the example embodiments without materially departing from "Screen Assembly and Methods of Use." Accordingly, all such modifications are intended to be included within the scope of this disclosure as defined in the following claims. In the claims, means-plus-function clauses are intended to cover the structures described herein as performing the recited function and not only structural equivalents, but also equivalent structures. Thus, although a nail and a screw may not be structural equivalents in that a nail employs a cylindrical surface to secure wooden parts together, whereas a screw employs a helical surface, in the environment of fastening wooden parts, a nail and a screw may be equivalent structures. It is the express

intention of the applicant not to invoke 35 U.S.C. § 112, paragraph 6 for any limitations of any of the claims herein, except for those in which the claim expressly uses the words 'means for' together with an associated function.

Claims

What is claimed is:

1. A screen assembly, comprising:
 - a base pipe having an axial bore formed therethrough;
 - an axial rod positioned radially-outward from the base pipe;
 - a screen positioned radially-outward from the axial rod;
 - a housing positioned radially-outward from the base pipe and axially adjacent to the axial rod, the screen, or both, wherein a first annulus is formed between the housing and the base pipe;
 - a first opening formed through the base pipe and radially-inward from the housing;
 - a second opening formed through the base pipe and radially-inward from the housing, wherein the second opening is axially offset from the first opening; and
 - a valve disposed within the first annulus and positioned axially between the first and second openings, wherein the valve allows a fluid to flow axially therethrough when in an open position and prevents the fluid from flowing axially therethrough when in a closed position.
2. The screen assembly of claim 1, wherein the axial rod has a third opening formed therethrough.
3. The screen assembly of claim 2, wherein a longitudinal axis through the third opening is substantially perpendicular to a longitudinal axis through the axial rod.
4. The screen assembly of claim 1, wherein a height of the axial rod varies between a first height, at which an inner surface of the axial rod is in contact with an outer surface of the base pipe, to a second height, at which the inner surface of the axial rod is spaced apart from the outer surface of the base pipe, thereby forming an opening between the inner surface of the axial rod and the outer surface of the base pipe.

5. The screen assembly of claim 1, further comprising an annular drainage layer positioned radially between the base pipe and the axial rod, wherein the drainage layer is adapted to have a fluid flow therethrough.
6. The screen assembly of claim 1, wherein an outer surface of the base pipe has a groove formed therein, and wherein the groove is positioned radially inward from the axial rod.
7. The screen assembly of claim 6, wherein the groove is an area of reduced outer diameter in the base pipe, and wherein the groove extends around a circumference of the base pipe.
8. The screen assembly of claim 1, further comprising a second housing positioned radially-outward from the base pipe, wherein a second annulus is formed between the second housing and the base pipe, and wherein the axial rod is positioned axially between the first and second annuli.
9. The screen assembly of claim 1, wherein the second opening has an inflow control device disposed therein to restrict fluid flow therethrough.
10. The screen assembly of claim 1, wherein a height of the axial rod is between about 10 mm and about 20 mm.
11. A screen assembly, comprising:
 - a base pipe having an axial bore formed therethrough;
 - an axial rod positioned radially-outward from the base pipe;
 - a screen positioned radially-outward from the axial rod, wherein first and second axial channels are formed between the screen and the base pipe, wherein the axial rod is positioned between the first and second axial channels, wherein an opening is formed through the axial rod, between the axial rod and the base pipe, or both, and wherein the opening provides a path of fluid communication between the first and second axial channels;

a housing positioned radially-outward from the base pipe and axially adjacent to the axial rod, the screen, or both, wherein an annulus is formed between the housing and the base pipe;

a radial opening formed through the base pipe and radially-inward from the housing;

an inflow control device formed in the base pipe and radially-inward from the housing, wherein the inflow control device is axially offset from the radial opening; and

a valve disposed within the annulus and positioned axially between the radial opening and the inflow control device, wherein the valve allows a fluid to flow axially therethrough when in an open position and prevents the fluid from flowing axially therethrough when in a closed position.

12. The screen assembly of claim 11, wherein the opening is formed through the axial rod.

13. The screen assembly of claim 11, wherein the opening is formed between the axial rod and the base pipe.

14. The screen assembly of claim 13, wherein a height of the axial rod varies between a first height, at which an inner surface of the axial rod is in contact with an outer surface of the base pipe, to a second height, at which the inner surface of the axial rod is spaced apart from the outer surface of the base pipe, thereby forming the opening between the inner surface of the axial rod and the outer surface of the base pipe.

15. The screen assembly of claim 13, wherein the opening is a groove formed in an outer surface of the base pipe.

16. A method of gravel packing an annulus between a screen and a wall of a wellbore, comprising:

flowing a gravel slurry into the annulus between the screen and the wall of the wellbore, wherein the gravel slurry comprises a plurality of gravel particulates and a carrier fluid;

flowing the carrier fluid through the screen and into a first axial channel formed between the screen and a base pipe positioned radially-inward therefrom, wherein the first

axial channel is circumferentially offset from a second axial channel, and wherein an axial rod is positioned between the first and second axial channels;

flowing a portion of the carrier fluid from the first axial channel to the second axial channel through an opening formed through the axial rod, between the axial rod and the base pipe, or both;

flowing the portion of the carrier fluid through the second axial channel and into an annulus formed between a housing and the base pipe, wherein the housing is axially offset from the axial rod, the screen, or both;

flowing the portion of the carrier fluid axially through a valve disposed within the annulus formed between the housing and the base pipe; and

flowing the portion of the carrier fluid through a first radial opening formed in the base pipe and into an axial bore formed through the base pipe.

17. The method of claim 16, further comprising actuating the valve to a closed position after the portion of the carrier fluid has flowed therethrough, wherein additional fluid is prevented from flowing through the valve when the valve is in the closed position.

18. The method of claim 17, wherein the additional fluid comprises hydrocarbons.

19. The method of claim 17, further comprising flowing the additional fluid through a second radial opening formed in the base pipe and into the axial bore, wherein the second radial opening is positioned axially between the axial rod and the first radial opening.

20. The method of claim 19, wherein the second radial opening has an inflow control device disposed therein.