

SAND CONTROL FILTER ASSEMBLY WITH MULTILAYER WOVEN WIRE FILTER MESH AND METHOD FOR MANUFACTURE THEREOF

5 TECHNICAL FIELD

The present disclosure relates generally to completion equipment utilized in conjunction with a subterranean well such as a well for recovery of oil, gas, or minerals. More particularly, the disclosure relates to sand control filter assemblies and methods for their manufacture.

10 BACKGROUND

Oil and gas wells may be completed in a producing formation containing fines and sand which may flow with the fluids produced from the formation, regardless of whether the well is completed as an open hole or as a cased hole. The fines and sand in the produced fluids can abrade and otherwise damage completion equipment, for example seals, pump
15 seats, rod pumps, completion tubing, and other completion equipment. To control and limit fines and sand propagation into the completion equipment, filters in the form of sand screens may be installed in the completion equipment string and gravel may be packed around the screen, for example adjacent a perforated casing section.

Such sand control filter assemblies are commonly constructed by installing one or more
20 screen jackets on a perforated base pipe. The screen jackets typically include a coarse filter layer, which may be formed by single wire wrapped around a plurality of longitudinally extending ribs, for example. Once installed on the base pipe, the ribs provide certain support to the layer and function as a stand-off between the screen and the base pipe to create a drainage layer for fluid travel. The filter assembly may further include an outer
25 protective member, such as a perforated shroud, for protecting from abrasion and impacts. Conventionally, screen jackets have been secured to the base pipe and sealed by welding or crimping a ring thereabout.

BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments are described in detail hereinafter with reference to the accompanying figures, in which:

Figure 1 is an elevation view in partial cross section of a well system according to an embodiment, including a plurality of sand control filter assemblies located in an open wellbore section;

Figure 2 is an enlarged elevation view in partial cross section of a portion of a well system according to an embodiment, including a plurality of sand control filter assemblies located in a cased wellbore section;

Figure 3 is a transverse cross section of a filter assembly of Figure 1 or 2 according to an embodiment, showing multiple filter layers of woven wire mesh sandwiched between a perforated base pipe and a perforated shroud;

Figure 4 is an axial cross section of the filter assembly of Figure 3;

Figure 5 is a perspective view of a swatch of woven wire volumetric mesh according to an embodiment for use in forming the multiple filter layers in the filter assembly of Figures 3 and 4;

Figure 6 is an elevation view of the perforated base pipe of the filter assembly of Figures 3 and 4;

Figure 7 is an elevation view of the perforated base pipe of Figure 6 being wrapped with woven wire mesh to form the multiple filter layers of the filter assembly of Figures 3 and 4;

Figure 8 is an exploded elevation view of the filter-wound base pipe and the shroud of the filter assembly of Figures 3 and 4;

Figure 9 is an elevation view of the filter assembly of Figure 8 passing through a die for swaging the shroud into intimate contact with the outer filter layer;

Figure 10 is an elevation view of the filter assembly of Figure 9 after swaging, showing ends of the shroud welded to the base pipe; and

Figure 11 is a flowchart depicting a method of manufacture as illustrated in Figures 6–10, according to an embodiment.

DETAILED DESCRIPTION

The foregoing disclosure may repeat reference numerals and/or letters in the various examples. This repetition is for the purpose of simplicity and clarity and does not in itself dictate a relationship between the various embodiments and/or configurations discussed. Further, spatially relative terms, such as “beneath,” “below,” “lower,” “above,” “upper,” “uphole,” “downhole,” “upstream,” “downstream,” and the like, may be used herein for ease of description to describe one element or feature’s relationship to another element(s) or feature(s) as illustrated in the figures. The spatially relative terms are intended to encompass different orientations of the apparatus in use or operation in addition to the orientation depicted in the figures.

Figure 1 is an elevation view in cross-section of a well system, generally designated 10, according to one embodiment. Well system 10 may include land drilling, completion, servicing, or workover rig 11. Although a land-based system is illustrated, teachings of the present disclosure may also be used in association with drilling and completion systems including offshore platforms, semi-submersible, and drill ships as well as any other well system satisfactory for completing a well. Rig 11 may be located proximate well head 13. A blow out preventer, christmas tree, and/or other equipment associated with servicing or completing a wellbore (not illustrated) may also be provided at well head 13. Similarly, rig 11 may also include a rotary table and/or top drive unit (not illustrated).

In the illustrated embodiment, a wellbore 12 extends through the various earth strata. Wellbore 12 has a substantially vertical section 14, the upper portion of which has cemented therein a casing string 16 with casing cement 17. Wellbore may also have a substantially horizontal section 18 that extends through a hydrocarbon bearing subterranean formation 20. As illustrated, substantially horizontal section 18 of wellbore 12 may open hole, i.e., uncased.

Positioned within wellbore 12 and extending from the surface is a tubing string 22. Annulus 23 is formed between the exterior of tubing string 22 and the inside wall of wellbore 12 or casing string 16. Tubing string 22 provides a conduit for formation fluids recovered in a completion zone to travel from formation 20 to the surface. Tubing string 22

is coupled to a completion string 25, which divides the completion zone into various production intervals 15a, 15b, ... 15_i adjacent to formation 20.

The completion string includes a plurality of filter assemblies 24, each of which is positioned between a pair of packers 26 that provide a fluid seal between the completion string 22 and wellbore 12, thereby defining the production intervals 15. Filter assemblies 24 function to filter sand, fines and other particulate matter out of the production fluid stream. Filter assemblies 24 may also be useful in controlling the flow rate of the production fluid stream.

Although Figure 1 illustrates completion string 22 and filter assemblies 24 being used in an open hole environment, such are equally well suited for use in cased wells. Figure 2 is an enlarged elevation view in partial cross-section of a well system of a well system 10' according to an embodiment, in which completion string 22 and filter assemblies 24 are used in a portion of wellbore 12' that is lined with casing 16. Prior to installation of filter assemblies 24, the casing 16, casing cement 17, and formation 20 have been perforated, such as by a perforating gun, creating openings 21 for flow of fluid from the formation into wellbore 12'.

Although Figures 1 and 2 illustrate one filter assembly 24 for each production interval 15, any number of filter assemblies 24 may be deployed within a production interval as appropriate. Additionally, even though Figures 1 and 2 illustrate filter assemblies 24 located in a horizontal section 18, 18' of wellbore 12, 12', respectively, filter assemblies 24 are equally well suited for use in deviated wellbores, vertical wellbores, multilateral wellbore and the like.

Figure 3 and 4 are transverse and axial cross sections, respectively, of filter assembly 24 according to an embodiment. Referring to both Figures 3 and 4, filter assembly 24 includes a central base pipe 30. Base pipe 30 is perforated, having apertures 32 radially formed through its walls along a given filter length. Each end of base pipe 30 (only one is illustrated) may include a connection 31, such as a threaded pin or box, for connecting filter assembly 24 along completion string 22 (Figure 1).

Multiple layers 34 of a woven wire mesh 35 are positioned directly about the outer circumference of base pipe 30 to cover the entire filter length. Unlike typical sand control screen assemblies of prior art, filter assembly 24 excludes the coarse conventional filter

layer formed of wire-wound longitudinal ribs that provides a drainage layer immediately adjacent to the outer circumference of the base. Instead, filter assembly 24 positions an inner wire-mesh filter 34a layer directly against base pipe 30. According to a preferred embodiment, two or more adjacent filter layers of woven wire mesh are provided. Figures 3 and 4 show three adjacent filter layers 34a, 34b, and 34c, each formed of a woven wire mesh, although a greater number may be used.

A tubular shroud 36 covers the outer filter layer 34c along the filter length. Shroud 36 is perforated, having apertures 38 radially formed through its walls. Shroud 36 protects filter layers 34a, 34b, and 34c from abrasion and impacts. According to an embodiment, shroud 36 is compressed and plastically deformed into intimate contact with filter layer 34c, thereby holding all filter layers 34a, 34b, and 34c in place and sealing the ends of the filter layers from sand ingress. The ends of shroud 36 may be welded to base pipe 30 with weld beads 39.

Figure 5 is a perspective view of a swatch of an exemplar woven wire mesh 35 used to form filter layers 34a, 34b, 34c (Figures 3–4). In one embodiment, woven wire mesh 35 may be characterized by an irregular wire weave, which creates a volumetric mesh. Such a volumetric mesh that is suitable for filtering applications is commercially available from GKD Solidweave, GKD-USA, Inc., Cambridge, Maryland, USA. As used herein, irregular wire weave means that each wire does not simply repeated pass over then under transverse wires in succession. Rather, each wire passes over and under differing numbers of transverse wires according to a complex pattern or randomly, thereby creating a mesh with an irregular pattern of raised ridges and lowered valleys.

For example, as shown in Figure 5, volumetric mesh 35 has a plurality of longitudinally-oriented wires 40a, 40b, ... 40_n interwoven with a plurality of transversely-oriented wires 42a, 42b, ... 42_m. A first transverse wire 42a is woven under wire 40a, above four adjacent wires 40b–40e, and under four adjacent wires 40f–40i. The adjacent transverse wire 42b is woven above wire 40a, under wire 40b, above three adjacent wires 40c–40e, under three adjacent wires 40f–40h, and above wire 40i. Following on, the next adjacent transverse wire 42c is woven above two wires 40a–40b, under wire 40c, above two wires 40d–40e, under two wires 40f–40g, above wire 40h, and under wire 40i. Such irregular weaving may continue, thereby creating a mesh with an irregular pattern of raised ridges 44 and lowered valleys 46.

Referring back to Figures 4 and 5, when multiple filter layers 34a, 34_i, 34_{i+1} of volumetric mesh 35 are stacked, these raised ridges 44 and lowered valleys 46 form a network of channels between the layers, thereby allowing drainage so that fluid entering the filter layers normal to the mesh can flow generally longitudinally along filter assembly 24 and through the filter layers 34 to reach apertures 32 in base pipe 30.

Although a volumetric mesh is illustrated and described herein, a regular, symmetrically-woven wire mesh may also be used to form filter layers 34. Each filter layer that is added alters the filter micron rating. Accordingly, a filter designer can selectively control the filtering capability by specifying both the individual micron rating of the woven wire mesh 35 and the total number of filter layers 34 to be used therewith. Equally, woven wire meshes of differing micron filter rating or materials, for example, may be used for different filter layers 34 as appropriate.

Figures 6–10 are elevation views of filter assembly 24 as it is created through the various steps of a manufacturing process according to one embodiment, and Figure 11 is a flowchart outlining the steps of the manufacturing process. Referring to Figures 6 and 11, at step 50, a perforated base pipe 30 is provided. Base pipe 30 has apertures 32 radially formed through its walls along a given filter length. Each end of base pipe 30 may include a connection 31, such as a threaded pin or box, for connecting filter assembly 24 along completion string 22 (Figure 1).

Next, referring to Figures 7 and 11, multiple filter layers 34, such as filter layers 34a, 34b, 34c, are disposed about base pipe 30. At step 52, woven wire mesh 35 is disposed directly adjacent about the outer circumference of base pipe 30 to form inner filter layer 34a. Although mesh 35 can be deployed in various ways, in one or more embodiments mesh 35 is wound onto base pipe 30, thereby enhancing ease of manufacture. One or more intermediate filter layers 34b of woven wire mesh may be provided. At step 54, woven wire mesh 35 is disposed, such as by winding, about inner filter layer 34a to form outer filter layer 34c. In one embodiment, the filter layers are helically wound, although other suitable methods of application may also be used.

With reference to Figures 8 and 11, at step 56, perforated shroud 36 is deployed over outer filter layer 34c. Shroud 36 is perforated, having apertures 38 radially formed through its walls. Shroud 36 protects filter layers 34 from abrasion and impacts.

As shown in Figures 9 and 11, at step 58 shroud 36 is swaged into intimate contact with the outer filter layer 34c. Shroud 36 is compressed and plastically deformed into intimate contact with filter layer 34c, thereby holding all filter layers 34a, 34b, and 34c in place and sealing the ends of the filter layers from sand ingress. In one embodiment, shroud 36 is swaged by passing the filter assembly through a die 70 that reduces the outer diameter of the shroud. Die 70 may include one or more rollers 72a, 72b, 72c. The swaging process compresses the multiple filter layers 34a, 34b, 34c together and holds them firmly in place. Moreover, the swaging process may act to seal the ends of the filter layers from sand ingress.

Finally, referring to Figures 10 and 11, at step 60, the ends of shroud 36 may be welded to base pipe 30, further securing and providing mechanical strength to filter assembly 24. Welds 39 are illustrated in Figure 10.

In summary, a filter assembly for downhole use and methods for manufacture thereof have been described. Embodiments of the filter assembly may generally have a perforated base pipe, an inner filter layer of a woven wire mesh disposed directly adjacent the outer circumference of the base pipe, an outer filter layer of a woven wire mesh disposed about the inner filter layer, and a perforated shroud disposed directly adjacent and in intimate contact with the outer filter layer. Embodiments of the method of manufacture may generally include providing a perforated base pipe, disposing woven wire mesh directly adjacent about the outer circumference of the base pipe to form an inner filter layer, disposing woven wire mesh about the inner filter layer to form an outer filter layer, positioning a perforated shroud about the outer filter layer, and swaging the shroud into intimate contact with the outer filter layer. Embodiments of the method of manufacture may also generally include providing a perforated base pipe, wrapping woven wire mesh directly about the outer circumference of the base pipe to form multiple filter layers, positioning a perforated shroud about the wrapped woven wire mesh, and swaging the shroud onto the wrapped woven wire mesh.

Any of the foregoing embodiments may include any one of the following elements or characteristics, alone or in combination with each other: At least one intermediate filter layer of a woven wire mesh disposed between the inner and outer filter layers; at least one filter layer of the group consisting of the inner and outer filter layers includes a volumetric mesh characterized by having an irregular weave; the at least one filter layer provides for

drainage through the filter assembly; the at least one filter layer defines a plurality of ridges and a plurality of valleys; the shroud defines first and second ends; the first and second ends of the shroud are welded to the base pipe; at least one filter layer of the group consisting of the inner and outer filter layers is helically wound about the base pipe; wrapping the woven wire mesh about the base pipe; wrapping the woven wire mesh about the base pipe in a helical orientation; disposing woven wire mesh disposed about the inner filter layer to form at least one intermediate filter layer between the inner and outer filter layers; at least one filter layer of the group consisting of the inner and outer filter layers includes a volumetric mesh characterized by having an irregular thickness; at least one filter layer forms generally longitudinal drainage channels through the filter assembly; welding the first and second ends of the shroud to the base pipe; swaging the shroud into intimate contact with the outer filter layer by passing the filter assembly through a die that reduces the outer diameter of the shroud; the die includes at least one roller; the inner and outer filter layers define first and second ends; sealing the inner and outer filter layers and the shroud to the base pipe by swaging the shroud; the woven wire mesh is a volumetric mesh characterized by having an irregular thickness; and the multiple filter layers provide for drainage through the filter assembly.

The Abstract of the disclosure is solely for providing a way by which to determine quickly from a cursory reading the nature and gist of technical disclosure, and it represents solely one or more embodiments.

While various embodiments have been illustrated in detail, the disclosure is not limited to the embodiments shown. Modifications and adaptations of the above embodiments may occur to those skilled in the art. Such modifications and adaptations are in the spirit and scope of the disclosure.

CLAIMS

1. A filter assembly for downhole use, comprising:

a perforated base pipe;

an inner filter layer of a woven wire mesh disposed directly adjacent the outer circumference of said base pipe;

an outer filter layer of a woven wire mesh disposed about said inner filter layer; and

a perforated shroud disposed directly adjacent and in intimate contact with said outer filter layer; wherein

at least one filter layer of the group consisting of said inner and outer filter layers includes a volumetric mesh characterized by having an irregular wire weave defined by a plurality of longitudinally-oriented wires interwoven with a plurality of transversely-oriented wires with at least one longitudinally-oriented wire being woven under a first number of transversely-oriented wires and then over a second number of transversely-oriented wires;

wherein the first number is different than the second number; and

wherein said at least one filter layer forms generally longitudinal drainage channels through said filter assembly.

2. The filter assembly of claim 1 further comprising:

at least one intermediate filter layer of a woven wire mesh disposed between said inner and outer filter layers.

3. The filter assembly of claim 1 wherein:

said at least one filter layer defines a plurality of ridges and a plurality of valleys.

4. The filter assembly of claim 1 wherein:

said shroud defines first and second ends; and

said first and second ends of said shroud are welded to said base pipe.

5. The filter assembly of claim 1 wherein:

at least one filter layer of the group consisting of said inner and outer filter layers is helically wound about said base pipe.

6. A method for manufacturing a filter assembly for downhole use, comprising:

providing a perforated base pipe;

disposing woven wire mesh directly adjacent the outer circumference of said base pipe to form an inner filter layer

disposing woven wire mesh about said inner filter layer to form an outer filter layer; positioning a perforated shroud about said outer filter layer; and

swaging said shroud into intimate contact with said outer filter layer; wherein at least one filter layer of the group consisting of said inner and outer filter layers includes a volumetric mesh characterized by having an irregular wire weave defined by a plurality of longitudinally-oriented wires interwoven with a plurality of transversely-oriented wires with at least one longitudinally-oriented wire being woven under a first number of transversely-oriented wires and then over a second number of transversely-oriented wires;

wherein the first number is different than the second number; and

wherein said at least one filter layer forms generally longitudinal drainage channels through said filter assembly.

7. The method of claim 6 further comprising:

wrapping said woven wire mesh about said base pipe.

8. The method of claim 7 further comprising:

wrapping said woven wire mesh about said base pipe in a helical orientation.

9. The method of claim 6 further comprising:

disposing woven wire mesh disposed about said inner filter layer to form at least one intermediate filter layer between said inner and outer filter layers.

10. The method of claim 6 wherein:

said at least one filter layer defines a plurality of ridges and a plurality of valleys.

11. The method of claim 6 wherein:

said shroud defines first and second ends; and

the method further comprises welding said first and second ends of said shroud to said base pipe.

12. The method of claim 6 further comprising:

swaging said shroud into intimate contact with said outer filter layer by passing said filter assembly through a die that reduces the outer diameter of said shroud.

13. The method of claim 12 wherein:

said die includes at least one roller.

14. The method of claim 6 wherein:

said inner and outer filter layers define first and second ends;

said shroud defines a first and a second end; and

the method further comprises sealing said inner and outer filter layers and said shroud to said base pipe by swaging said shroud.

15. A method for manufacturing a filter assembly for downhole use, comprising:

providing a perforated base pipe;

disposing multiple filter layers directly adjacent the outer circumference of said base pipe, wherein at least one of said multiple filter layers includes a volumetric woven wire mesh characterized by having an irregular wire weave defined by a plurality of longitudinally-oriented wires interwoven with a plurality of transversely-oriented wires with at least one longitudinally-oriented wire being woven under a first number of transversely-oriented wires and then over a second number of transversely-oriented wires;

wherein the first number is different than the second number;

positioning a perforated shroud over said multiple filter layers; and

swaging said shroud on to said multiple filter layers.

16. The method of claim 15 further comprising:

wrapping woven wire mesh directly about the outer circumference of said base pipe to form said multiple filter layers.

17. The method of claim 16 wherein:

said volumetric woven wire mesh forms generally longitudinal drainage channels through said filter assembly.

18. The method of claim 15 wherein:

said shroud defines first and second ends; and

the method further comprises welding said first and second ends of said shroud to said base pipe.

19. The method of claim 15 further comprising:

swaging said shroud by passing said filter assembly through a die that reduces the outer diameter of said shroud.