A centralizer device that is set by expansion of an inner expandable tubular member. The centralizer is made up of either one or a plurality of centralizer bands which radially surround an inner, radially expandable tubular member. Each of the centralizer bands includes one or more expansion sections which buckle under tension to form a loop. Generally semicircular, opposing tension straps are affixed to opposite end portions of the expansion section. The tension straps underlie the expansion section and radially surround the inner tubular member in a close-fitting, snug relation. A closure mechanism is used to secure each centralizer band to the inner tubular member.
EXPANDABLE TUBULAR CENTRALIZER

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention
[0002] The invention relates generally to centralizer devices that are used with expandable tubular members.
[0003] 2. Description of the Related Art
[0004] During drilling, production or other operations within a borehole, it is often desired to utilize a device for stabilizing or centralizing a tool string within the borehole. Often, centralizers are constructed of rib-like springs that bow outwardly from the tool string.
[0005] A centralizer device that can be used with a radially expandable tubular is described in U.S. Pat. No. 7,140,431.

SUMMARY OF THE INVENTION

[0006] The present invention provides a centralizer device for use with an inner radially expandable tubular member. The centralizer can be moved between a first, unset condition and a second, set condition. The centralizer is set by expansion of the inner expandable tubular member. In one described embodiment, the centralizer is made up of a plurality of centralizer bands which radially surround the inner, radially expandable tubular member. Each of the centralizer bands includes an expansion section which can be buckled to form a loop. Generally semicircular tension straps are affixed to opposite end portions of the expansion section. The tension straps underlie the expansion section and radially surround the inner tubular member in a close-fitting, snug relation. A closure mechanism is used to secure each centralizer band to the inner tubular member. In an alternate embodiment, the centralizer is a single band having multiple expansion sections.

[0007] To move the centralizer to a set condition, the inner tubular member is radially expanded which exerts tension on the tension straps. The expansion sections of each centralizer band buckle and are bent into a radially protruding loop. The loop formed by each expansion section will contact the interior radial surface of a surrounding tubular member and retaining the inner tubular member in a spaced relation away from the outer tubular member.

[0008] Either a single band or a plurality of centralizer bands are used to make up the centralizer. In a described embodiment, each of the centralizer bands is oriented such that its expansion section is radially offset from the expansion sections of the other centralizer bands. Preferably, the expansion sections of the centralizer bands are angularly spaced apart from one another using generally equal spacing, thereby ensuring that the inner tubular member will be generally centered within the outer tubular member when the centralizer is set.

[0009] Devices constructed in accordance with the present invention permit a radially expandable tubular member to be centralized within an outer tubular member according to methods of the present invention. In accordance with methods of the present invention, a centralizer device, formed of one or more centralizer bands, is disposed about the circumference of the expandable tubular member. Thereafter, the expandable tubular member and centralizer device are disposed within an outer tubular member. The expandable tubular member is then radially expanded, causing the centralizer to move from the unset condition to the set condition. When the centralizer device is in the set condition, the expandable tubular member is centralized within the outer tubular member by contact between the loops formed by the expansion section(s) of the one or more centralizer bands and the surrounding outer tubular member.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] For a thorough understanding of the present invention, reference is made to the following detailed description of the preferred embodiments, taken in conjunction with the accompanying drawings, wherein reference numerals designate like or similar elements throughout the several figures of the drawings and wherein:

[0011] FIG. 1 is an external, isometric view of an exemplary centralizer, in accordance with the present invention, which is surrounding a radially expandable inner tubular member and in a pre-expansion condition.

[0012] FIG. 2 is an external, isometric view of the centralizer and inner tubular member of FIG. 1, now with the tubular member in a radially expanded condition.

[0013] FIG. 3 is an axial cross-sectional view of an exemplary centralizer and inner tubular member in a pre-expansion condition and within an outer tubular member.

[0014] FIG. 4 is an axial cross-sectional view of the centralizer and inner tubular member of FIG. 3, now with the inner tubular member having been radially expanded.

[0015] FIG. 5 is an external, isometric view of a single exemplary centralizer band.

[0016] FIG. 6 is a further external, isometric view of the centralizer band shown in FIG. 5.

[0017] FIGS. 7-9 are detail views of the centralizer band shown in FIGS. 5 and 6 depicting aspects of the centralizer band in its unset condition.

[0018] FIG. 8A illustrates an exemplary hinge type connection used with a centralizer band.

[0019] FIG. 10 is an external, isometric view of the centralizer band shown in FIGS. 5-9, now in a set condition.

[0020] FIGS. 11 and 12 are further external, isometric views of the centralizer band shown in FIGS. 5-9, now in a set condition.

[0021] FIG. 13 illustrates an alternative embodiment for a centralizer constructed in accordance with the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0022] FIGS. 1-12 depict an exemplary centralizer, generally indicated at 10, disposed upon an expandable inner tubular member 12 which presents an outer radial surface and which has a circumference. In embodiments, the inner tubular member 12 may comprise a production tubing string or an expandable liner, of a type known in the art. The centralizer 10 is made up of at least one, but preferably a plurality of, centralizer bands 14, 16, 18, 20, 22 and 24 which radially encircle the tubular member 12 in preferably a close-fitting, snug relation, so that the centralizer bands do not easily slide or rotate their positions upon the outer radial surface of the tubular member 12.

[0023] In the depicted embodiment, the centralizer bands 14, 16, 18, 20, 22 and 24 each have an identical construction. FIGS. 5-12 illustrate an exemplary centralizer band 14 apart from the other components of the centralizer 10. The exemplary centralizer band 14 includes a generally rectangular, arcuately curved expansion section 26 that can be selectively
buckled to be expanded radially outwardly. First, generally semicircular tension bands 28, 30 underlie the expansion section 26. The tension bands 28, 30 are affixed to one arcuate end 32 of the expansion section 26. Preferably, as depicted best in FIG. 7, the tension bands 28, 30 are extensions of the material forming the expansion section 26 and are folded under the expansion section 26 at folds 34. As an alternative to folding extensions of the material forming the expansion section 26 under the expansion section 26, the tension bands 28, 30 might be formed by affixing the tension bands 28, 30 to the arcuate end 32 of the expansion section 26 using pins or other connectors of a type known in the art. It is noted that, while there are two, parallel tension bands 28, 30 shown affixed to the arcuate end 32 of the expansion section 26, there might be more or fewer than two. However, at least one tension band is affixed to the arcuate end 32. The tension bands 28, extend about the circumference of the inner tubular member 12.

[0024] Another tension band 36 is affixed to an opposite arcuate end 38 of the expansion section 26. In one embodiment, best seen in FIG. 8, the tension band 36 is an extension of the material forming the expansion section 26 and is folded under the expansion section 26 at fold 40. In an alternative embodiment, shown in FIG. 8A, the tension band 36 is affixed by a hinge 37 to the arcuate end 38 of the expansion section 26. The hinge 37 may resemble a standard door hinge and receive hinge pin 39. This method of attachment readily permits the expansion section 26 to be fashioned from a different material than that making up the tension band 36. For example, the expansion section 26 might be formed of fiberglass while the tension band 36 is formed of sheet metal.

[0025] As best seen in FIG. 7, the tension band 36 preferably resides between the two tension bands 28, 30. The exemplary tension bands 28, 30 may be thought of as a first tension band that is affixed to a first arcuate end 32 of the expansion section 26. The tension band 36 may be thought of as a second tension band, which is affixed to a second arcuate end 38 of the expansion section 26 and which opposes the first tension band.

[0026] An exemplary closure mechanism 42 for the centralizer band 14 is illustrated in FIG. 9. In the depicted closure mechanism 42, end portions of each tension band 28, 30, 36 are curved and folded to form pin retainer portions 44 which align with one another. A pin 46 is then removably inserted into the pin retainer portions 44. In order to secure the centralizer band 14 around the inner tubular member 12, the pin 46 is removed from the pin retainer portions 44 and the centralizer band 14 is then placed to surround the inner tubular 12. The pin retainer portions 44 are then aligned with one another, and the pin 46 is inserted into the pin retainer portions 44. Preferably, multiple centralizer bands are disposed around the inner tubular member 12 with the expansion portions 26 of the various centralizer bands being radially offset from one another about the circumference of the inner tubular member 12. This permits the centralizer to provide roughly even centralization and spacing from a surrounding tubular member. In the example depicted in FIGS. 1-4, there are six centralizer bands 14, 16, 18, 20, 22 and 24, each of which having its expansion section 26 disposed in a generally equally angularly spaced relation to one another about the circumference of the inner tubular member 12 (i.e., approximately 60 degrees apart).

[0027] The centralizer 10 is actuated from its unset position (FIGS. 1, 3 and 5-8) to its set position (FIGS. 2, 4, and 10-12) as the inner tubular member 12 is radially expanded from an unexpanded condition (see FIG. 1) to a radially expanded condition (see FIG. 2). The inner tubular member 12 may be expanded radially outwardly by fluid pressure or by mechanical swaging or by other techniques known in the art. As the inner tubular member 12 expands radially, the tension bands 28, 30 are placed in tension against the tension band 36. The arcuate end 32 of the expansion section 26 is urged closer to the second arcuate end 38. The expansion section 26 of each centralizer band 14, 16, 18, 20, 22, 24 buckle and form a loop that expands as the inner tubular member 12 expands further eventually contacting the interior radial surface 48 of a surrounding outer tubular member 50. See FIG. 4. The expansion sections 26 retain the inner tubular member 12 in a spaced relation from the outer tubular member 50, thereby centralizing the inner tubular member 12 within the outer tubular member 50.

[0028] The components of the centralizer bands 14, 16, 18, 20, 22 and 24 may be formed from materials that are capable of transmitting significant tension through the tension bands 28, 30, 36 and which permit the expansion section 26 to deform into a loop, as described. In currently preferred embodiments, the centralizer bands 14, 16, 18, 20, 22 and 24 are made of sheet metal. However, other suitable materials may also be used.

[0029] FIG. 13 illustrates an alternative centralizer 10' which has been constructed in accordance with the present invention. In FIG. 13, the centralizer 10' is depicted in an unrolled fashion and apart from a tubular member 12. The centralizer 10' includes four expansion sections 26 which are depicted in an unset state. The expansion sections 26 are interconnected with one another by tension bands 28, 30 and 36. It is noted that, while four expansion sections 26 are shown, there may be more or fewer than four, if desired. It is currently preferred that there be roughly equivalent spacing between expansion sections 26 so that when affixed to an expandable tubular member and moved to the set position, the expanded sections 26 will have a substantially equal angular spacing about the circumference of the tubular member. The ends 52, 54 of the centralizer 10' may be joined to each other with the use of pins or other connectors, as are known in the art. It is noted that the use of multiple expansion sections 26 on a single centralizer band eliminates having to adjust the angular orientation of expansion sections 26 of multiple centralizer bands, such as 14, 16, 18, 20, 22 and 24.

[0030] The present invention also provides inventive methods for centralizing an inner expandable tubular member 12 within a surrounding outer tubular member 50. In an exemplary method, a centralizer, made up of one or more centralizer bands 14, 16, 18, 20, 22 and/or 24, is disposed around the circumference of the inner expandable tubular member 12. The inner expandable tubular member 12 is in an unexpanded condition, and the centralizer bands 14, 16, 18, 20, 22 and/or 24 are in an unset condition at this time. Preferably, the centralizer bands 14, 16, 18, 20, 22 and/or 24 are secured around the inner tubular member 12 in a snug, close-fitting relation. Preferably also, the centralizer bands 14, 16, 18, 20, 22 and/or 24 are secured around the inner tubular member 12 in a snug, close-fitting relation. As described previously.

[0031] The inner tubular member 12 and affixed centralizer 10 are thereafter disposed within the outer tubular member 50 (see FIG. 3). Next, the inner tubular member 12 is radially expanded from the unexpanded condition depicted in FIGS. 1
and 3 to the radially expanded condition shown in FIGS. 2 and 4. As the inner tubular member 12 is radially expanded, the centralizer bands 14, 16, 18, 20, 22 and/or 24 are moved from their unset condition to their set condition. Radial expansion of the inner tubular member 12 causes the first tension bands 28, 30 to exert tension on the first arcuate end 32 of the expansion section 26, while the second tension band 36 exerts tension on the second arcuate end 38 of the expansion section 26. As a result, the arcuate ends 32, 38 are urged closer toward each other causing the expansion section 26 to buckle and form a loop. The loop of the expansion section 26 for each centralizer band 14, 16, 18, 20, 22 and/or 24 will contact the outer tubular member 50 to centralize the inner tubular member 12 within the outer tubular member 50.

[0032] Those of skill in the art will recognize that numerous modifications and changes may be made to the exemplary designs and embodiments described herein and that the invention is limited only by the claims that follow and any equivalents thereof.

What is claimed is:
1. A centralizer for a radially expandable tubular member having an outer radial surface with a circumference, the centralizer comprising:
   - a centralizer band which radially surrounds the expandable tubular member and comprises:
     - an arcuate expansion section overlying a portion of the outer radial surface of the expandable tubular member, the expansion section having first and second arcuate ends and being deformable into a loop as the first and second arcuate ends are moved toward each other;
     - a first, generally semi-circular tension band affixed to the first arcuate end and extending about a portion of the circumference of the expandable tubular member; a second tension band affixed to the second arcuate end and extending about a portion of the circumference of the expandable tubular member; and
     - the first and second tension bands being secured to each other;
   - a retaining pin that is secured within the pin retainer portions.

9. The centralizer of claim 1 wherein at least one of the first and second tension bands is affixed to the expansion section by a hinge.

10. A centralizer for a radially expandable tubular member having an outer radial surface with a circumference, the centralizer comprising:
   - a centralizer band, said centralizer band radially surrounding the expandable tubular member and comprising:
   - an arcuate expansion section overlying a portion of the outer radial surface of the expandable tubular member, the expansion section having first and second arcuate ends and being deformable into a loop as the first and second arcuate ends are moved toward each other;
   - a first, generally semi-circular tension band affixed to the first arcuate end and extending about a portion of the circumference of the expandable tubular member;
   - a second tension band affixed to the second arcuate end and extending about a portion of the circumference of the expandable tubular member;
   - the first and second tension bands being secured to each other; and
   - wherein expansion of the expandable tubular member moves the centralizer from an unset condition, wherein the expansion section of the centralizer band is not deformed into a loop, to a set condition wherein the expansion section is deformed into a loop.

11. The centralizer of claim 10 wherein there is a plurality of centralizer bands forming the centralizer.

12. The centralizer of claim 11 wherein the expansion section of each of the plurality of centralizer bands is angularly offset from the expansion sections of other centralizer bands.

13. The centralizer of claim 12 wherein the expansion sections of the centralizer bands are generally equally angularly spaced relative to one another about the circumference of the expandable tubular member.

14. The centralizer of claim 11 wherein there are six centralizer bands forming the centralizer.

15. The centralizer of claim 10 wherein the centralizer band has multiple expansion sections.

16. The centralizer of claim 10 further comprising a closure mechanism for securing the first tension band to the second tension band, the closure mechanism comprising:
   - pin retainer portions formed in each of the first and second tension bands; and
   - a retaining pin that is secured within the pin retainer portions.

17. The centralizer of claim 10 wherein at least one of the first and second tension bands is affixed to the expansion section by a hinge.

18. A method for centralizing an inner, radially expandable tubular member within an outer tubular member, the method comprising the steps of:
   - disposing a centralizer around the inner tubular member, the centralizer comprising at least one centralizer band having:
     - an arcuate expansion section having first and second arcuate ends and being deformable into a loop as the first and second arcuate ends are moved toward each other;
a first, generally semi-circular tension band affixed to
the first arcuate end and extending about a portion of
the circumference of the inner expandable tubular
member;
a second tension band affixed to the second arcuate end
and extending about a portion of the circumference of
the inner tubular member;
disposing the inner tubular member and the centralizer
within an outer tubular member; and
radially expanding the inner expandable tubular member,
the radial expansion causing the centralizer bands to
move from an unset condition to a set condition, thereby
centralizing the inner tubular member within the outer
tubular member.
19. The method of claim 18 wherein the at least one cen-
tralizer band is moved from the unset to the set condition by:
the first and second tension bands exerting tension upon
arcuate ends of each expansion section to cause the
expansion section to buckle and form a loop.

20. The method of claim 18 wherein the step of disposing
a centralizer around the inner tubular member further com-
promises:
disposing multiple centralizer bands around the inner tubu-
lar member such that the expansion sections of each
centralizer band is angularly offset from the expansion
sections of other centralizer bands.
21. The method of claim 20 wherein the expansion sections
of the centralizer bands are generally equally angularly
spaced relative to one another about the circumference of the
inner tubular member.
22. The method of claim 18 wherein the step of disposing
the centralizer around the inner tubular member further com-
promises securing the at least one centralizer band by fastening
a closure mechanism.
23. The method of claim 18 wherein the step of disposing
a centralizer around the inner tubular member further com-
promises:
disposing a centralizer band with multiple expansion sec-
tions around the inner tubular member.