A method and apparatus for cementing an annulus wellbore is described herein. The apparatus includes an internally radiused portion of a sleeve adapted for increasing the compressive strength of a compound for securing a valve in the sleeve. The internally radiused portion prevents the apparatus from leaking during operation. The apparatus is manufactured using one pass of a milling tool. The apparatus is run into a wellbore. A cementing operation in performed past the apparatus. The apparatus then prevents the cement from entering a downhole tubular.
STRESS REDUCED CEMENT SHOE OR COLLAR BODY
CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims benefit of U.S. provisional patent application Ser. No. 60/865,981, filed Nov. 15, 2006, which is herein incorporated by reference in its entirety.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] Embodiments disclosed herein generally relate to an apparatus and method of making and/or using a downhole shoe and/or collar. More particularly, the embodiments disclosed herein relate to shoe and collars for use in downhole cementing operations. More particularly still, the embodiments disclosed herein relate to float shoes and collars configured with an internal radius profile configured to reduce leaking around the valve and through the body of the float shoe and float collar, while increasing the compression capability of the apparatus.

[0004] 2. Description of the Related Art

[0005] In the drilling of oil and gas wells, a wellbore is formed using a drill bit that is rotated downwardly at a lower end of a drill string. After drilling a predetermined depth, the drill string and bit are removed and the wellbore is lined with a string of casing. An annular area is thus formed between the string of casing and the wellbore. A cementing operation is then conducted in order to fill the annular area with cement.

The combination of cement and casing strengthens the wellbore and facilitates the isolation of certain areas of the formation behind the casing for the production of hydrocarbons.

[0006] It is common to employ more than one string of casing in a wellbore. In this respect, a first string of casing is set in the wellbore when the well is drilled to a first designated depth. The first string of casing is hung from the surface, and then cement is circulated into the annulus behind the casing. The well is then drilled to a second designated depth, and a second string of casing or liner is run into the well. The second string of casing or liner is also cemented. This process is typically repeated with additional casings or liners until the well has been drilled to total depth.

[0007] In a conventional cementing operation a float shoe is attached to the bottom of the casing string as the casing string is run into the wellbore. The float shoe typically has a one-way valve located within the shoe. The casing is run into the wellbore to the desired depth and a cementing operation is performed. The cementing operation commences with a first plug being dropped into the casing. The first plug typically has a through bore with a rupture disk therein. Behind the plug, cement is pumped into the casing. Following the cement, a second typically solid plug is dropped into the casing. The first plug lands on the float shoe. As the pressure of the cement behind the first plug increases, the ruptured disk fails. The cement flows through the bore of the first plug and past the one-way valve in the float shoe until the second plug reaches the first plug. The one-way valve allows the cement to flow out of the float shoe and into the annulus between the casing and the wellbore therearound while preventing the cement from reentering the casing string.

[0008] The float shoe typically comprises a collar 100 with angular wickers 102 formed on the internal diameter of the collar 100, as shown in FIG. 1. A wicker is a circumferential groove that is not typically helical in the interior of the float shoe. The upper end of the collar 100 couples to the casing. The interior of the collar 100 includes a one-way valve 106, which is held in place by a cured cement 108. The lower end of the float shoe has a rounded nose 110 formed of the cured cement 108. A bore 112 is created in the cured cement 108 to allow the cementing operation cement to flow past the one way valve 106 and the float shoe. The angular wickers 102 provide an irregular surface which enables the cured cement to be adequately retained with the collar 100. The angular wickers 102 place a compressive stress on the cured cement when the shoe is loaded from either end. The angular wickers 102 include a downward facing shoulder 114, a flat wall 115, and an upward facing shoulder 116.

[0009] As the float shoe is run into the wellbore, back pressure is applied to the float shoe. Back pressure is pressure on the downhole side of the float shoe. Back pressure may be created in various ways. A dynamic back pressure is created during the run in of the float shoe. The dynamic back pressure is simply the resistance of the wellbore fluids on the float shoe as it is lowered into the wellbore. A static back pressure may be created due to wellbore fluids in the annulus 203 having a greater pressure than fluid inside the float shoe and casing.

The back pressure may be created during testing of the float shoe, either downhole or before running into the wellbore. Further, the nose may encounter objects on the bottom of the wellbore as it is run in. The back pressure and/or the weight of the casing will place stress on the cured cement 108. The plugs used during the cement operation will impact the float shoe and thereby place a pump pressure on the top side of the float shoe. The bump pressure places the concrete into compression between the upheole side of the float shoe and the upward facing shoulders 116 as the pressure behind the plugs increases.

[0010] In the float shoe, stress risers occur at angles Θ and φ of the angular wickers 102, as shown in FIG. 1A. As back pressure, bump pressure, and weight are placed on the float shoe, the cement 108 is placed in compression. The compression is distributed over the float shoe as a pressure. The pressure applies a force F to the angled wickers 102 in a direction normal to each surface, downward facing shoulder 114, a flat wall 115, and an upward facing shoulder 116 of the angular wicker 102. The force F applied to the surfaces 114, 115, and 116 of the angled wickers 102 create stress risers 122 at angles Θ and φ. These stress risers 122 are increased areas of stress in the cement 108. The stress risers 122 locally place the cement 108 in tension in some instances. The high tensile stress in the cement 108 at the stress riser 122 causes failure of the cement 108. That failure may cause leak paths to form along the interior of the sleeve. Further, the back pressure or the bump pressure may cause a shear stress between the cured cement 108 in the angular wickers 102 and the cured cement 108 outside of the angular wickers 102. The shear stress causes further failure of the cement and the float shoe.

[0011] The traditional float shoes, as shown in FIG. 1, have small leak paths along the angular wickers 102 that form due to shrinkage of the cured cement 108. Back pressure and/or bump pressure can crack or further crack the cured cement along the stress riser paths 122 formed by the angular wickers 102, thereby creating or exacerbating leakage along leak paths. The stresses on the rounded noses 110 of the float shoe create a failure of the nose at a location 120. The failure in the rounded nose 110 causes the nose to fall off at relatively low back pressures. With the rounded nose 110 off, the stress in
the remaining cured cement 108 is enhanced and the leak paths allow increased volumes of fluids to flow past the float shoe.

[0012] The angles $\Theta$ and $\phi$ on the float shoe require the angular wickers to be machined from two axial directions. For example, when machining from the rounded nose 110 end of the collar 100, it is only possible to cut angles $\Theta$ and $\phi$ of the downward facing shoulder 114. Thus, the collar 100 is placed on the lathe and machined in a first axial direction to cut one of the shoulders 114 or 116. The collar is then placed on the lathe and the same process is repeated from a second axial direction. The angles $\Theta$ and $\phi$ of the angular wickers 102, in reality, have a small radius. This small radius is caused by machining limitations. More precise cutting tools will reduce the small radius; however, the small radius is always less than $1/2"$. It is known to use float shoes or float collars that only require cutting in one direction. However, these float shoes or float collars have only one sharp angled shoulder 114 or 116. Therefore, these float shoes or float collars hold high pressure in only one axial direction. That is the float shoe or float collars are only capable of holding back pressure or bump pressure but not both.

[0013] Therefore a need exists for float shoes or float collars capable of holding bi-directional pressure. There is a further need for a float valve having an increased resistance to leaking and failure. There is a further need of float shoes or float collars that can be manufactured with a one pass machining operation.

SUMMARY OF THE INVENTION

[0014] Embodiments described herein relate to a cementing assembly. The cementing assembly has a sleeve having an internal profiled portion. The internal profiled portion includes a first radius portion culminating in a first minimum radius toward an exterior of the sleeve and a second radius portion culminating in a second minimum radius toward interior of the sleeve. The cementing assembly further includes a bore located in the interior or the sleeve and a compound for coupling the valve to the sleeve wherein the first minimum radius and the second minimum radius are configured to reduce stress risers in the compound.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] So that the manner in which the above recited features of the present invention can be understood in detail, a more particular description of the invention, briefly summarized above, may be had by reference to embodiments, some of which are illustrated in the appended drawings. It is to be noted, however, that the appended drawings illustrate only typical embodiments of this invention and are therefore not to be considered limiting of its scope, for the invention may admit to other equally effective embodiments.

[0016] FIG. 1 is a cross-sectional view of a float shoe.

[0017] FIG. 1A is a view of one angular wicker.

[0018] FIG. 2 is a cross-sectional view of a wellbore according to one embodiment described herein.

[0019] FIG. 3 is a cross-sectional view of a float shoe according to one embodiment described herein.

[0020] FIG. 4 is a view of the inner profiled portion according to one embodiment described herein.

[0021] FIG. 5 is a cross-sectional view of a float collar according to one embodiment described herein.

[0022] FIG. 6 is a cross-sectional view of a component according to one embodiment described herein.

[0023] FIG. 7 is a cross-sectional view of a wellbore.

DETAILED DESCRIPTION

[0024] FIG. 2 shows a cross-sectional view of a wellbore 200 according to one embodiment described herein. The wellbore 200 has a tubular 202 which is being run into and set in the wellbore 200. Between the wellbore 200 and the tubular 202 is an annulus 203. The tubular 202, as shown, is a casing; however, it could be any wellbore tubular such as a liner, a drill string, a production tubing, a coiled tubing, etc. The tubular 202 is run into the wellbore 200 to a desired location. A cementing operation is then performed in order to fix the tubular 202 in place and isolate production zones, not shown, located within the wellbore 200. The tubular 202 is coupled at its lower end to a valve assembly 204, shown schematically. The valve assembly 204 has a valve 206, a bore 208, a sleeve 210, and a compound 212. The valve assembly 204, as shown, is a float shoe; however, it is contemplated that a float collar or any other cementing assembly may be used. The valve 206 is shown and described as a one-way valve or check valve; however, other valves may be used such as a flapper valve, a gate valve, a pop-off valve, or that no valve is used. Further, although shown as having one valve 206, any number of valves may be used in order to increase reliability of the valve assembly. The sleeve 210 includes a radius inner profile, discussed in more detail below, configured to reduce stresses in the compound 212 while retaining the compound 212 in the sleeve 210.

[0025] The cementing operation is performed by dropping a first plug 214, shown schematically, into the interior bore of the tubular 202. The first plug 214 is followed by a cement 216 for cementing the annulus 203 and a second plug 218, shown schematically. The second plug 218 is pushed down hole by a pumping fluid, not shown. The pumping fluid may be any fluid capable of pushing the second plug 218 through the tubular 202, such as drilling mud, water, etc. The first plug 214 travels down the tubular until it lands on the valve assembly 204. With the first plug 214 engaged with the valve assembly 204, a bump pressure is created between the first plug 214 and the valve assembly 204. As the pumping fluid pressure increases behind the second plug 218, the pressure increases in the cement 216 thereby increasing bump pressure on the valve assembly 204. The bump pressure increases until a rupture disk (not shown) bursts on the first plug 214. With the rupture disk burst, the cement 216 flows through the first plug 214 into the bore 208 to the valve 206. Initially when the rupture disk bursts, a portion of the bump pressure is relieved from the top of the valve assembly 204. The fluid pressure of the cement may then open the valve 206 or the valve may be remotely opened depending on the valve. The cement 216 then flows past the valve assembly 204 and into the annulus 203. The cement 216 continues to flow out into the annulus 203 until the second plug 218 lands on the first plug 214. With the second plug 218 on the first plug 214, continued pressuring of the pumping fluid increases the bump pressure on the valve assembly 204. The valve 206 may then close in order to prevent the cement 216 from flowing back into the tubular 202 or U-tubing.

[0026] The cement 216 is allowed to cure in the annulus 203. A milling or drilling tool then lowers into the tubular 202 in order to mill out the second plug 218, the first plug 214, and the valve assembly 204. If necessary, the wellbore 200 may be
drilled lower and any number of additional tubulars 202 placed into the wellbore 200 in the same manner as described above.

[0027] FIG. 3 shows a cross sectional view of the valve assembly 204, according to one embodiment described herein. The valve assembly 204 includes the sleeve 305, the valve 206, a compound 300 for holding the valve 206 in the sleeve 210, and the bore 208 formed in the compound 300. In one embodiment, the compound 300 is cement; however, the compound could be a composite, an impregnated cement, a polymer, or any suitable compound, preferably a castable compound. The compound forms a nose 301 at the lead end and a seat 302 at the up-hole end of the valve assembly 204. The valve 206, as shown, is a one-way valve having a body 303, a plunger 304, and a biasing member 306 for biasing the plunger 304 toward the closed position. The biasing member 306 is shown as a coiled spring; however, it should be appreciated that the biasing member may be any member capable of biasing the valve 206 toward the closed position, such as a resilient member, a leaf spring, a fluid bias, etc.

[0028] The sleeve 305 has a connector end 307, an internally profiled portion 308, and a lead end 312. The connector end 307 is shown as a box end of a threaded connection for coupling the valve assembly 204 to the tubular 202; however, it is contemplated that the connector end 307 be any type of connection for use in a downhole setting, such as a pin end, a welded connection, etc. The internally profiled portion 308, as shown, has a plurality of radiused portions which have a series of hills 314 and valleys 316. The hill 314 is any part of the internal profiled portion 308 which culminates toward the interior of the sleeve 305. The valley 316 is any part of the internal profiled portion which culminates toward the exterior of the sleeve 305. FIG. 4 shows a view of one segment of the internally profiled portion 308. The distance between the hills 314 is shown as X. The hill 314 has a radius R1. The distance between the peak of the hill 314 and the valley 316 is shown as the depth D. The depth D is typically greater than 0.08 inches. Typically the depth D is 0.125 inches, 0.15 inches, or 0.2 inches; however, it should be appreciated that the depth D may be any depth desired. The valley 316 has a radius R2. The radii R1 and R2 are the minimum radius of the hill 314 and the valley 316 on the internally profiled portion 308. In the embodiment shown in FIG. 3, the ratio of R1 to R2 is 2:1 and the distance X is 2 inches. One advantage to design herein disclosed is to create an undulated surface with no abrupt changes from one radius to the next.

[0029] The internal profiled portion 308 is designed to be manufactured with one pass of a cutting tool, not shown. The cutting tool passes through the sleeve 305 as the sleeve is rotated on a lathe. The cutting tool cuts away the valleys 316 of the internal profiled portion 308. By cutting the valleys 316, the hills 314 are formed at the peaks of the valleys 316. Due to the gradual change in the radius of the valleys 316 and the hills 314, the forming of the hills 314 and valleys 316 does not require the cutting tool to cut the sleeve in two axial directions. Thus, the sleeve 305 may be placed on a lathe and the cutting tool may enter the sleeve from either the nose end or the connector end of the sleeve 305 and cut the internal profiled portion 308 in one pass and/or in one cutting direction. Therefore, the manufacturing time is greatly decreased from traditional angular wickers, which require the milling tool to cut in both directions in order to form the wickers. Alternatively, the sleeve 305 may be manufactured by hydro-forming, roll forming, or any other suitable technique.

[0030] In operation, the valve assembly 204 is coupled to the lower end of the tubular 202, as shown in FIG. 2. The valve assembly 204 and tubular 202 are then lowered into the wellbore 200 by a rig until they reach a desired depth. A back pressure may be present on the valve assembly 204 during run-in. The back pressure creates a force on the nose 301. The back pressure may also create a force on the interior of the valve 206 in addition to the force on the nose 301. The force on the nose 301 and the valve assembly 204 immediately places the compound 300 located in the valleys 316 into compression. The compression in the valleys 316 helps seal the interior of the sleeve 305, thereby preventing fluids from leaking past the valve assembly 204.

[0031] The back pressure may remain on the valve assembly 204 until and/or during and after the cementing operation. The first plug 214 drops into the tubular 202 to commence the cementing operation. The first plug 214 is followed by the cement 216 and the second plug 218. The first plug 214 creates the bump pressure on the seat 302 upon engagement. The bump pressure places the compound 300 in compression. The first plug 214 increases the bump pressure on the seat 302 until the rubber disk of the first plug 214 is set off. The cement 216 in front of the second plug 218 enters the bore 208 and puts pressure on the up hole side of the plug 304. The pressure on the up hole side of the plug 304 is increased by increasing the pumping pressure behind the second plug 218. The up hole pressure on the plug 304 will continue to rise until the force on the up hole side of the plug 304 is greater than the force of the biasing member 306 and the force created by any back pressure. The up hole pressure then moves the plug 304 to create a flow path for the cement to flow past the valve 206. The pumping fluid continues to push the second plug 216 down until the second plug reaches the first plug 214. With the second plug 216 on top of the first plug, the cement 216 is in the annulus 203. The pumping pressure may be relieved from the second plug 216. The up hole pressure on the plug 304 decreases until the biasing member 306 overcomes the pressure and closes the valve 206. The valve 206 prevents the cement 216 from reentering the tubular 202. The cement is allowed to cure. The first plug 214, the second plug 216, the compound 300, and the valve 206 may then be drilled or milled out to allow access to locations below the valve assembly 204. The entire process may be repeated as needed.

[0032] The stresses created in the compound 300 due to back pressure and bump pressure are greatly reduced due to the radiused internal profiled portion 308. The gradually changing angles of the hills 314 and the valleys 316 prevent large stress risers from occurring in the internal profiled portion 308. The radiused profiles further provide a larger load bearing surface area than traditional angular wickers. The larger surface area reduces the stresses created by the bump pressure and the back pressure. Because the stress risers and stresses are reduced in the compound 300, the valve assembly 204 is capable of higher loading than the traditional angular wicker float shoes. Therefore, the geometry of the internal profiled portion 308 prevents the nose 301 from failing while back pressure is applied to the valve assembly 204. For example, the typical prior art float shoe nose fails and breaks at about 4,000 psi of back pressure. The nose 301 of the valve assembly 204 described herein has been tested at 10,000 psi of back pressure without failing, cracking, or leaking.

[0033] FIG. 5 depicts an alternative embodiment of the valve assembly 204. A float collar 500 has an internal profiled portion 508 similar to that of the internal profile portion 308.
The float collar 500 includes a valve 504 having a plunger 505 and a biasing member 506. The valve 504 is secured in the interior of the float collar 500 with a compound 507. The compound 507 is similar to the compound 300 discussed above. The float collar 500 further includes a spacer 510, optional, which provides additional space for a bore 512. The spacer 510 may be any length and allows the float collar 500 to be manufactured with a longer internal profiled portion 508. The spacer 510 is shown having a radiused exterior similar to the internal profiled portion 508; however, it should be appreciated that the exterior of the spacer 510 may have any configuration. The spacer 510 may be incorporated into any of the embodiments described herein. The internal profiled portion 508 includes one or more hills 514 and one or more valleys 516 which operate in the same manner as described above. The hills 514 and valleys 516 are radiused as described above. The float collar 500 has an up hole connector 509 and a downhole connector 518. As shown, the up hole connector 509 is a threaded box connection and the downhole connector 518 is a threaded pin end. The downhole connector may be connected to a bottom hole assembly (BHA), tools, or a second tubular, not shown. The float collar operates in the same manner as the valve assembly 204.

Although the radius R1 and R2 are described above as having a 2:1 radius ratio, it is contemplated that the R1 and R2 are substantially equal. In an alternative embodiment R2 may be larger than R1. Further, the radius of each hill 314/514 and each valley 316/516 of the internal profiled portion 308/508 may vary from one hill or valley to the next hill and valley. The minimum length of R1 and R2 required to prevent high stress risers from forming the compound 300 and 507 is greater than 1/2 inches.

In yet another embodiment, the tangent point between the Radii R1 and R2 is approximately 1/2 of the depth D from the hill 316. That is, the radius R1 bends into R2 at a location which is approximately 1/2 of the depth D from the hill 316. The second radius R2 of the valley 314, in this configuration, is where most of the cement is in compressive contact with the internal profiled portion 308/508 when loading.

In an alternative embodiment, the internal profiled portion 308/508 is one or more spiraled or helical grooves, as opposed to circumferential grooves, that extend along the interior of the valve assembly 204.

In an alternative embodiment, the internal profiled portion 308/508 is a plurality of separate dimples which may extend circumferentially and/or axially in the tubular. The interaction between the dimples and the compound 212 would be similar to that of the internal profiled portion 308/508 and the compound 212.

In an alternative embodiment, the internal profile may have irregular radii R1 and R1 and have varying dimensions X and D. Further, the radiused portions may be intermittent and/or spaced apart from one another. These examples are not meant to limit the internal profile to these geometries.

In the above embodiments the internal profile has been described in conjunction with the valve assembly 204; however, it should be appreciated that other components may be used in addition to or as an alternative to the valve assembly 204. In Fig. 6 a component 600 held in a tubular 602 by the compound 212 which engages the component and the internally profiled portion 308, as described above. The tubular 602, as shown, may be a joint or a full string of casing or production tubing; or, may relatively short tubular or a collar which is within a longer tubular string. The tubular 602 includes the internally profiled portion 308 which acts to reduce the force in the compound during operation of the component 600. In addition or alternative to the internally profiled portion 308, a component profile 604 and/or an outer tubular profile 606 accompany the component 600 and/or the tubular 602. The component profile 604 and the outer tubular profile 606 may have any of the shapes described herein. The component profile 604 in turn has the stress paths of the compound 212 in the same manner as described above. As shown in FIG. 6, the component 600 is a location profile in the tubular 602. The location profile is adapted to engage a tool that is dropped or pumped into the tubular 602. The location profile may be adapted to catch and/or seat any suitable downhole tool including, but not limited to, a dart, a ball, a downhole pump, another tubular string, a packer for example a swell packer or an inflatable packer, an expansion tool, pump down floats, expandable casing, or a whipstock.

The outer tubular profile 606 may be used in conjunction with the inner profiles 308 and component 600, or may be used independent of inner profile 308 and the component 600. Any tubular 602 in which a component is applied to the outer diameter of the tubular 602 may include the outer tubular profile 606. For example, the tubular 602 may be a casing run into a wellbore. The casing may have one or more outer tubular profile 606 portions along the entire length of the casing.

When the casing 702 is cemented into a wellbore 700, as shown in FIG. 7, the cement 704 is pumped into an annular space between the exterior of the casing and the wall of the borehole, where it hardens. The profiled portion 308/508 enable the cement to achieve a robust bond to the casing. This is advantageous in promoting a seal, eliminating problems with micro-anuli between casing and cement. Additionally, this enables the casing to be supported against axial loading. For example, during the life of the well, the casing may be subjected to temperature cycling caused by periods of production or injection punctuated by periods in which the well is closed-in. The casing would therefore be subjected to axial stress cycles due to thermally-induced expansion and contraction. Such lengthening and shortening can lead to a breakdown of the bond between the casing and the surrounding cement. This degradation can lead to development of fluid leak paths past (or through) the cement, and/or loss of structural support provided by the cement. Such issues may be particularly problematic in high temperature, geothermal and steam injection wells. However, casing provided with outer profiles (such as profiles 606 illustrated shown in FIGS. 6 and 7) interacts with the surrounding cement in the same way as the internal profiles 308 interact with compound 212 described above. Hence this casing is more robust against axial stresses (such as thermally-induced stresses). Shear forces within the surrounding cement are better resisted due to the absence of stress risers at or near the casing-cement interface. Therefore, breakdown of the cement and/or the casing-to-cement bond is hindered, thereby mitigating the above problems.

Further, an inner tubular profile (not shown) may be located at a particular point on the inner diameter of a tubular string, or along the entire inner diameter of the tubular string. The inner tubular profile would act in a similar manner to the profiles 308, 604, and 606 described above. The inner tubular profile may provide a landing point for tools to be run into the wellbore after the tubular string has been run in.

Further, the component 600 may be any suitable downhole tool secured to the tubular 602 by a compound.
example the component may be a valve, a baffle, a pressure transducer, a sensor, an actuator, a motor, a whipstock, or electronics.

[0044] In an additional or alternative embodiment, the internal space of apparatus 204/500/602 may be filled with compound 212, thereby forming a plug without the component. Alternatively, the component 600 may be present, but may include a solid component without a throughbore in order to assume the configuration of a plug. The plug would act to restrict fluid flow between the upstream and downstream portion of the plug, and would be able to hold increased pressure on either side of the plug due to the stress reducing capabilities of the internal profile portion 308.

[0045] While the foregoing is directed to embodiments of the present invention, other and further embodiments of the invention may be devised without departing from the basic scope thereof, and the scope thereof is determined by the claims that follow.

1. An apparatus for installation in a wellbore, comprising:
a sleeve having an internal profiled portion, wherein the internal profiled portion includes:
a first radius portion culminating in a first minimum radius toward an exterior of the sleeve; and
a second radius portion culminating in a second minimum radius toward an interior of the sleeve;
a bore located in the interior of the sleeves; and
a compound for coupling a component to the sleeve wherein the first minimum radius and the second minimum radius are configured to reduce stress risers in the compound.

2. The apparatus of claim 1, wherein the component is a valve.

3. The apparatus of claim 1, wherein the transition from the first minimum radius to the second minimum radius is accomplished by a continually changing radius.

4. The apparatus of claim 1, wherein the first minimum radius is larger than the second minimum radius.

5. The apparatus of claim 1, wherein the ratio between the first minimum radius and the second minimum radius is 2:1.

6. The apparatus of claim 1, wherein the first minimum radius is smaller than the second minimum radius.

7. The apparatus of claim 1, wherein the first minimum radius is the same as the second minimum radius.

8. The apparatus of claim 1, wherein the internal profiled portion is undulated.

9. The apparatus of claim 1, wherein the first minimum radius and the second minimum radius are larger than \( \frac{5}{8} \text{"} \).

10. The apparatus of claim 2, wherein the valve is a one-way valve coupled to the bore.

11. The apparatus of claim 1, wherein the internal profiled portion forms a sinuousoidal wave.

12. The apparatus of claim 1, wherein the internal profiled portion forms a spiral pattern.

13. The apparatus of claim 1, wherein the cementing assembly is a float shoe.

14. The apparatus of claim 1, wherein the cementing assembly is a float collar.

15. The apparatus of claim 1, further comprising a box end connection for connecting the cementing assembly to a casing string.

16. The apparatus of claim 15, further comprising a pin end connection for connecting the assembly to a bottom hole assembly.

17. The apparatus of claim 1, wherein a tangent point between the first radius portion and the second radius portion is located at a distance of \( \frac{1}{2} \) the depth between the culminating of the first minimum radius and the culminating in the second minimum radius.

18. The apparatus of claim 1, wherein the internal profiled portion extends circumferentially around an interior wall of the sleeve.

19. A method for manufacturing a cementing assembly, comprising:
providing a sleeve;
running a tool into the interior of the sleeve;
forming an undulated internal profile in the sleeve; and
fixing a component to the interior of the sleeve using a compound.

20. The method of claim 19, wherein the compound is a cement.

21. The method of claim 19, wherein the tool is a cutting tool.

22. The method of claim 21, wherein forming the undulated internal profile in the sleeve comprises cutting the interior of the sleeve with the cutting tool.

23. The method of claim 22, wherein cutting the interior of the sleeve is accomplished with the cutting tool entering the sleeve from only one end of the sleeve.

24. The method of claim 23, wherein the cutting is accomplished in only one pass of the cutting tool in one axial direction.

25. The method of claim 23, wherein the cutting is accomplished in multiple passes.

26. The method of claim 25, wherein the multiple passes are in only one axial direction.

27. The method of claim 19, wherein the undulated internal profile in the sleeve is formed circumferentially around the interior of the sleeve.

28. An apparatus, comprising:
a tubular body defining a longitudinal axis, an internal wall surface and an external wall surface,
a profile in the internal wall surface, including a concave portion defined by a first radius transitioning into a convex portion defined by a second radius; and
a bonding compound in contact with the profile, wherein the profile is configured to substantially minimize stress within the compound upon the application of an axial shear load to the compound.

29. The apparatus of claim 28, wherein the profile extends circumferentially around the internal wall surface of the tubular body.

30. The apparatus of claim 28, further comprising a component coupled to the compound.

31. The apparatus of claim 30, wherein the component is a valve.

32. An apparatus, comprising:
a tubular body defining a longitudinal axis, an internal wall surface and an external wall surface,
a profile in the external wall surface, including a concave portion defined by a first radius transitioning into a convex portion defined by a second radius; and
a bonding compound in contact with the profile, wherein the profile is configured to substantially minimize stress within the compound upon the application of an axial shear load to the compound.

33. The apparatus of claim 32, wherein the tubular body is a casing and the compound is a cement.

34. The apparatus of claim 33, wherein the profile extends circumferentially around the external wall surface of the tubular body.