A glow plug has a heater probe that can be axially misaligned relative to a central axis of an outer metal shell and of a center electrode and thereafter return automatically to its axially aligned configuration with the central axis. The outer shell has a through bore extending along the central axis. The center electrode is received in the through bore and extends along the central axis. The heater probe is attached in electrical communication with the center electrode in the through bore and extends along the central axis axially outwardly from a distal end of the shell. An annular flex joint provides the sole source of attachment of the outer shell to the heater probe via one end of the flex joint being attached to the outer shell adjacent the distal end and another end of the flex joint being attached to the heater probe.
GLOW PLUG WITH PERMANENT DISPLACEMENT RESISTANT PROBE TIP JOINT

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims the benefit of U.S. Provisional Application Ser. No. 61/315,439, filed Mar. 19, 2010, which is incorporated herein by reference in its entirety.

BACKGROUND OF THE INVENTION

[0002] 1. Technical Field
[0003] This invention relates generally to glow plugs, and more particularly to ceramic glow plugs.
[0004] 2. Related Art
[0005] Ceramic glow plugs typically have an outer metal shell with a ceramic heater probe fixed partially therein. The heater probe extends axially outwardly from the shell to a distal probe tip and axially into the shell to a proximal end configured for attachment to a center electrode. The heater probe is preferably maintained in coaxial alignment with a central axis of the metal shell and the center electrode, such that the distal probe tip extends into the cylinder bore in an intended location to insure optimal ignition results. However, sometimes the heater probe can be plastically deformed by being bent out of axial alignment with central axis of the shell and center electrode, such as during assembly or handling in general. When this occurs, the glow plug is generally rendered inoperable.

SUMMARY OF THE INVENTION

[0006] A glow plug constructed in accordance with the invention has a heater probe that can be axially misaligned relative to a central axis of an outer shell and of a center electrode within the shell by an externally applied radial force, and thereafter return automatically substantially to its original axially aligned configuration with the central axis of the shell and center electrode upon removing the applied force without the glow plug being damaged. The metal outer shell has a through bore extending along the central axis between a proximal end and a distal end. The center electrode is received in the through bore and extends along the central axis. The heater probe is attached in electrical communication with the center electrode in the through bore and extends along the central axis. The flex joint provides the sole source of attachment of the outer shell to the center electrode. The flex joint has one end attached to the outer shell adjacent to the distal end and another end attached to the center electrode. The flex joint has an annular leg extending radially between the outer shell and the center electrode. As such, if an external force is applied to the plane of the flex joint, the flex joint allows the heater probe to temporarily axially out of axial alignment with the outer shell and the center electrode, while automatically biasing the heater probe back to, or substantially back to, its axially aligned position relative to the shell and center electrode upon release of the externally applied force. Accordingly, the glow plug can withstand inadvertent bending of the heater probe without becoming plastically deformed or otherwise damaged.

[0007] In accordance with another aspect of the invention, the flex joint has a reverse folded portion extending axially between the outer shell and heater probe.

[0008] In accordance with another aspect of the invention, the flex joint has a double, Z-shaped reverse folded portion extending axially between the outer shell and heater probe.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] These and other aspects, features and advantages of the invention will become more readily appreciated when considered in connection with the following detailed description of presently preferred embodiments and best mode, appended claims and accompanying drawings, in which:

[0010] FIGS. 1A-1D illustrates a test to assess the ability of a glow plug heater probe to withstand a force applied laterally to the heater probe tip;

[0011] FIG. 2 shows a glow plug constructed in accordance with one aspect of the invention; and

[0012] FIGS. 3A-3G show enlarged cross-sectional views of various configurations of the area designated 3A-3G in FIG. 2 in accordance with the invention.

DETAILED DESCRIPTION OF PRESENTLY PREFERRED EMBODIMENTS

[0013] Referring more detail to the drawings, FIG. 2 illustrates a glow plug 10 constructed in accordance with one presently preferred embodiment of the invention. The glow plug 10 has an annular outer metal shell 12 with an inner surface 13 bounding a through bore 14 which extends along a longitudinal central axis 15 of the shell 12 between a proximal end 17 and a distal end 19. The metal shell 12 may be formed from any suitable metal, such as various grades of steel, and may also incorporate a plating or coating layer, such as a nickel or nickel alloy coating on an exterior, also referred to as outer surface 16, and the bore 14, to improve the resistance of shell 12 to high temperature oxidation and corrosion. The glow plug 10 also includes a heater assembly 18. The heater assembly 18 has a heater probe 20 and a center electrode 22 attached to the heater probe 20. In accordance with the invention, an annular flex joint as shown in various configurations in FIGS. 3A-3G, and indicated as 24 in FIG. 3A, fixes the heater probe 20 to the shell 12. As shown in FIGS. 1B-1C, the flex joint 24 allows the heater probe 20 to temporarily flex axially out of axial alignment with the longitudinal axis 15 relative to the outer shell 12 and the center electrode under an externally applied force (F) over a lateral displacement (D1), while automatically biasing the heater probe 20 back to, or substantially back to, its axially aligned position relative to the shell 12 and center electrode 22 (FIG. 1D) such that any residual displacement (D2) is negated or negligible. Accordingly, the heater probe 20, upon being bent out of axial alignment from the longitudinal axis 15 can return automatically back to axial alignment with the axis 15, and thus, can withstand inadvertent bending without becoming permanently or plastically deformed or otherwise damaged.

[0014] The flex joint 24 is preferably constructed of a material having a relatively low Young's modulus and high yield strength. In addition, the material preferably is selected having a thermal expansion coefficient closely matched with the material of the heater probe 20, such as Kovar, Thermospans, Inconel 903, Inconel 718 or the like, to allow direct attachment of the flex joint 24 to the heater probe 20. The flex joint 24 can be attached to the shell 12 by an interference fit,
brazing, or welding, for example, and to the heater probe 20 by brazing, particularly for ceramic probes, and by an interference fit, brazing or welding, particularly for metal probes. [0015] As shown in FIG. 3A, the flex joint 24 extends between opposite free ends 26, 28, wherein one free end 26 extends radially outwardly from the axis 15 and is attached directly to the inner surface 13 of the shell 12 in a butt joint immediately adjacent the free distal end 19 of the shell 12. The free end 19 is shown having an annular chamfered surface, also referred to as nose 42, that extends obliquely to the central axis 15 generally toward the proximal end 17 of the shell 12 and, or substantially to the outer surface 16 of the shell. The flex joint 24 has a single reverse fold 30, with an annular leg 32 extending axially and generally parallel with the axis 15 from the free end 26 toward the center electrode 22 to the reverse fold 30 and another annular leg, also referred to as an annular collar 34, extending axially and generally parallel with the axis 15 from the reverse fold 30 toward a free end or tip 36 of the heater probe 20. As such, the leg 32 extends axially between the shell 12 and the collar 34 in a detiched relation therefrom with an annular gap or space 37 being formed between the leg 32 and shell 12 and an annular space being formed between the leg 32 and collar 34. The collar 34 has an inner, radially inwardly facing annular surface 38 that is attached to an outer surface 40 of the heater probe 20. The bond is formed via one of the mechanisms discussed above and extends substantially along the length of the collar 34, wherein the collar 34 extends from adjacent the nose 142 axially away from the shell 112.

[0018] Another flex joint 224 constructed in accordance with the invention is shown in FIG. 3C, wherein similar reference numerals, offset by a factor of 200, are used to identify like features as discussed above. The flex joint 224 is similar the flex joint 124, however, rather than having a lip everted over a nose of a shell 212, a surface 244 adjacent a free end 226 is attached to an inner surface 213 of the shell 212 adjacent the nose 242, with the free end 226 shown being flush with the nose 213, by way of example and without limitation. Otherwise, the flex joint 224 is the same as the flex joint 124, including having a single reverse fold 230, with a pair of an annular legs 232, 232' extending generally axially in generally parallel relation with one another, although in a slight angular relation with the axis 215, from the reverse fold 230 toward a tip 236 of the heater probe 220. The fold 232 transitions to a cylindrical collar 234, wherein the collar 134 is attached to an outer surface 240 of the heater probe 220. A pair of annular gaps or spaces 237, 237' are formed between the legs 232, 232' and shell 212 and heater probe 220, respectively, and an annular space 239 is formed between the legs 232, 232'. A radially inwardly facing surface 238 of the collar 234 is attached to the outer surface 240 of the heater probe 220, wherein the bond is formed via one of the mechanisms discussed above.

[0019] Another flex joint 324 constructed in accordance with the invention is shown in FIG. 3D, wherein similar reference numerals, offset by a factor of 300, are used to identify like features as discussed above. The flex joint 324 is similar the flex joint 24 of FIG. 3A, however, rather than having a free end attached to an inner surface 313 of a shell 312, a radially outward facing surface 344 of a radially outer first leg, also referred to as outer collar 334', is attached to the inner surface 313 of the shell 312, while a radially outer second leg, also referred to as inner collar 334, is attached to an outer surface 340 of the heater probe 320 as discussed above for FIG. 3A. The outer collar 334' and inner collar 334 are attached along their full length to the respective inner surface 313 and outer surface 340. Rather than having a single reverse fold as in the previous embodiments, the outer collar 334' provides the flex joint 324 with a pair of reverse folds 330, 330' with an annular third leg 332 extending axially and generally parallel with the axis 315. The third leg 332 extends axially between the outer collar 334' and the inner collar 334 in detached, radially spaced relation therefrom. An annular gap or space 337 is formed between the legs 332 and outer collar 334' and an annular space 339 is formed between the legs 332 and the inner collar 334. Accordingly, the leg 332 and outer collar 334' are spaced radially from one another and the leg 332 and the inner collar 334 are spaced radially from one another. The collars 334, 334' and third leg 332 are in radially aligned configuration with one another forming a generally
Z-shaped wall in axial cross-section such that the gaps 337, 339 are also radially aligned with one another. The inner collar 334 is attached to the heater probe 320 as discussed above with regard to FIG. 3A.

[0020] Another flex joint 424 constructed in accordance with the invention is shown in FIG. 3E, wherein similar reference numerals, offset by a factor of 400, are used to identify like features as discussed above. The flex joint 424 is similar the flex joint 324 of FIG. 3D; however, rather than having the full length of an outer first leg, also referred to as outer collar 434, attached to an inner surface 413 of a shell 412, only a portion of the outer collar 434 immediately adjacent a free end 426 is attached to the inner surface 413, while a portion of the outer collar 434' adjacent a reverse fold 430 located adjacent and radially inwardly from a nose 442 remains detached radially inward from the inner surface 413 of the shell 412. Likewise, rather than having the full length of an inner second leg, also referred to as inner collar 434, attached to an outer surface 440 of a heater probe 420, only a portion of the inner collar 434 immediately adjacent a free end 428 is attached to the outer surface 440, while a portion of the inner collar 434 adjacent a reverse fold 430 located between the shell 412 and the heater probe 420 remains detached from the outer surface 440 of the heater probe 420. The outer collar 434 provides the flex joint 424 with a pair of reverse folds 430, 430' with an annular third leg 432 extending axially and generally parallel, though slightly angled with respect to an axis 415. The third leg 432 extends axially between the outer collar 434' and the inner collar 434 in detached relation therefrom. An annular gap or space 437 is formed between the third leg 432 and outer collar 434' and an annular space 439 is formed between the third leg 432 and the inner collar 434. The collars 434, 434' and third leg 432 are in a radially aligned configuration with one another forming a generally Z-shaped wall in axial cross-section such that the gaps 437, 439 are also radially aligned with one another.

[0021] Another flex joint 524 constructed in accordance with the invention is shown in FIG. 3F, wherein similar reference numerals, offset by a factor of 500, are used to identify like features as discussed above. The flex joint 524 has similarities to the flex joint 24 of FIG. 1, in that it extends between opposite free ends 526, 528, wherein one free end 526 extends radially outwardly from an axis 515 and is attached directly to an inner surface 513 of the shell 512 in a butt joint. Further, a leg 532 extends radially inwardly generally transverse to the axis 515 and transitions directly to a cylindrical second end, also referred to as collar 534. The collar 534 extends axially toward a tip 536 of the heater probe 520 and is fixed to an outer surface 540 of the heater probe 520 as discussed above with regard to the collar 34 of FIG. 3A. As such, rather than a reverse folded leg providing the flex joint 524 with the ability to flex angularly relative to the axis 515, it is the radially extending annular leg 532 that provides the freedom to flex. Accordingly, the degree of elastic flex can be regulated by controlling the length of the leg 532, with the flex increasing and decreasing as the length is increased and decreased, respectively.

[0022] Another flex joint 624 constructed in accordance with the invention is shown in FIG. 3G, wherein similar reference numerals, offset by a factor of 600, are used to identify like features as discussed above. The flex joint 624 is similar to the flex joint 524, having opposite free ends 626, 628, wherein one free end 626 extends radially outwardly from an axis 615 and is attached directly to an inner surface 613 of the shell 612 in a butt joint. Further, a leg 632 extends radially inwardly generally transverse to the axis 515 and transitions directly to a cylindrical second end, also referred to as collar 634. The collar 634 extends axially toward a tip 636 of the heater probe 620 and is fixed to an outer surface 640 of the heater probe 620 via one of the mechanisms discussed above with regard to the collar 34 of FIG. 3A. However, rather than the entire length of the collar 634 being attached to the heater probe 620, as with the collar 534 discussed above, only a distal portion of the collar 634 immediately adjacent the free end 628 is attached to the heater probe 620. An axially proximal portion of the collar 634 immediately adjacent the leg 632 remains spaced radially from and detached from the heater probe 620, with an annular space 637 preferably being formed between the collar 634 and the heater probe 620. Accordingly, an increase degree of angular elastic deflection is provided by the gap 637.

[0023] Obviously, many modifications and variations of the present invention are possible in light of the above teachings. It is, therefore, to be understood that within the scope of the appended claims, the invention may be practiced otherwise than as specifically described.

What is claimed is:
1. A glow plug, comprising:
a metal outer shell having a through bore extending along a central axis between a proximal end and a distal end;
a center electrode received in said through bore and extending along said central axis;
a heater probe attached in electrical communication with said center electrode in said through bore and extending along said central axis axially outwardly from said distal end of said shell; and
an annular flex joint providing the sole source of attachment of said outer shell to said heater probe, said flex joint having one end attached to said outer shell adjacent said distal end and another end attached to said heater probe, said flex joint having an annular leg extending radially between said outer shell and said heater probe.

2. The glow plug of claim 1 wherein said leg has at least one portion extending substantially parallel to said central axis in axially spaced relation with said shell and said heater probe.

3. The glow plug of claim 2 wherein said leg has at least a pair of portions extending substantially parallel to one another between said shell and said heater probe.

4. The glow plug of claim 3 wherein said leg is generally Z-shaped.

5. The glow plug of claim 4 wherein a first portion of said Z-shaped leg is fixed to said shell, a second portion of said Z-shaped leg is fixed to said heater probe, and a third portion extend between said first portion and said second portion with a radial clearance formed between said first, second and third portions.

6. The glow plug of claim 5 wherein a portion of said first portion is detached in radially spaced relation from said shell.

7. The glow plug of claim 6 wherein a portion of said second portion is detached in radially spaced relation from said heater probe.

8. The glow plug of claim 5 wherein said first portion is entirely attached to said shell.

9. The glow plug of claim 8 wherein said second portion is entirely to said heater probe.

10. The glow plug of claim 5 wherein said first, second and third portions are spaced radially from one another.
11. The glow plug of claim 1 wherein said distal end of said shell has a chamfered nose extending toward an outer surface of said shell and said one end of said flex joint being everted over said chamfered nose in bonded relation thereto.

12. The glow plug of claim 1 wherein said annular leg transitions to a cylindrical portion extending axially outwardly from said distal end of said shell.

13. The glow plug of claim 1 wherein said cylindrical portion is entirely fixed to said heater probe.

14. The glow plug of claim 1 wherein said cylindrical portion has a portion spaced radially from said heater probe and a portion fixed to said heater probe.

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