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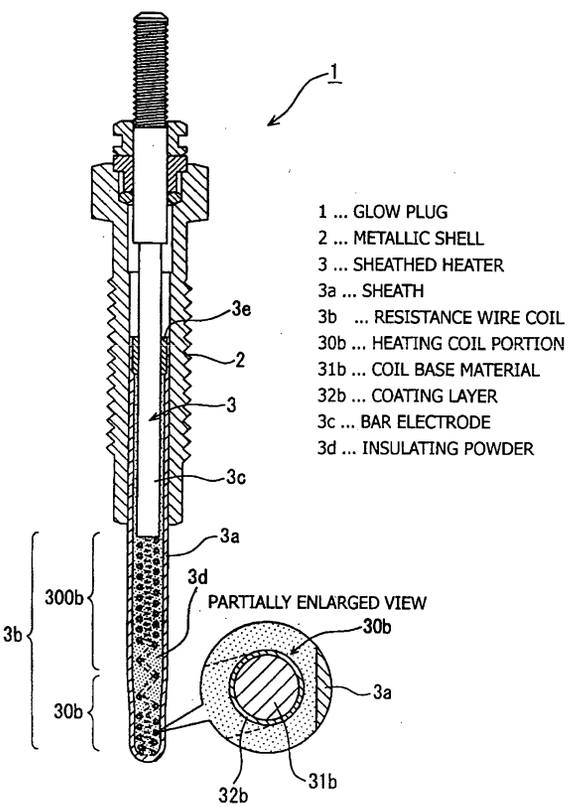
(54) Glow plug

(57) A glow plug 1 includes a sheathed heater 3 and a metallic shell 2. The sheathed heater 3 is configured such that a resistance wire coil 3b having a heating coil portion 30b and an insulating MgO powder 3d are placed in a sheath 3a and such that a bar electrode 3c is inserted into the sheath 3a. The heating coil portion 30b is formed of, for example, an Fe-Cr-A1 alloy, which exhibits, for example, excellent heat resistance. However, when the temperature of the heating coil portion 30b exceeds 1,000°C, there arises a phenomenon that the heating coil portion 30b fails to exhibit expected durability. An object of the present invention is to provide the glow plug 1 that exhibits excellent durability at high temperature, particularly a high temperature in excess of 1,000°C. The heating coil portion 30b is formed by a coil base material 31b and a coating layer 32b, which covers the surface of the coil base material 31b, and the coating layer 32b is formed of Pt, Pd, Rh, or an alloy of two or more of Pt, Pd, and Rh.

Fig. 1



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Description

[0001] The present invention relates to a glow plug used, for example, to preheat a diesel engine.

Prior Art:

[0002] A so-called self-control-type glow plug will be described with reference to FIG. 2. A glow plug 1 is composed substantially of a tubular metallic shell 2 and a sheathed heater 3, which extends axially through the metallic shell 2.

The sheathed heater 3 is configured as follows: while a resistance wire coil 3b—which consists of a heating coil portion 30b located on the side toward the distal end of the resistance wire coil 3b and a control coil portion 300b located on the side toward the rear end of the resistance wire coil 3b—and a distal end portion of a bar electrode 3c are placed in a sheath 3a made of a heat-resisting metal, whose distal end is closed in a substantially hemispherical shape and whose rear end is open, the sheath 3a is filled with an insulating MgO (magnesium oxide) powder 3d, and an insulating rubber packing 3e is interposed between the bar electrode 3c and the inner surface of an opening portion of the sheath 3a to thereby seal the opening. The bar electrode 3c is disposed such that its distal end is located in a longitudinally intermediate portion of the interior of the sheath 3a and electrically connected to the resistance wire coil 3b (control coil portion 300b), whereas its rear end extends along the axis of the metallic shell 2 and projects outward therefrom. The resistance wire coil 3b (heating coil portion 30b) is electrically connected to the inner surface of the closed distal end of the sheath 3a. Accordingly, the bar electrode 3c and the sheath 3a are electrically connected together via the resistance wire coil 3b.

[0003] The resistance wire coil 3b of the self-control-type glow plug 1 is configured such that the heating coil portion 30b and the control coil portion 300b are connected in series. Mainly the heating coil portion 30b generates heat to cause the distal end of the sheath 3a to glow, whereas the control coil portion 300b rapidly increases in electric resistance with temperature to suppress current flowing to the heating coil portion 30b. As has just been described, in the resistance wire coil 3b, the heating coil portion 30b and the control coil portion 300b have respective roles. Material is selected as appropriate in accordance with the roles. For example, an Fe-Cr alloy or an Ni-Cr alloy, each of which exhibits excellent resistance to oxidation and heat, is used to form the heating coil portion 30b; and in order that its electric resistance sensitively reflects a change in temperature, pure Fe or the like, which has a high positive temperature-resistance coefficient, is used to form the control coil portion 300b (refer to, for example, Patent Document 1). In the glow plug of Patent Document 1, pure Fe is employed as material for the control coil portion 300b, and, in order to enhance oxidation resistance of the pure Fe, the surface of an Fe wire is plated with Ni or Cr.

[0004] Needless to say, material having excellent resistance to heat and oxidation is selected as material for the heating coil portion 30b. However, when the temperature of the heating coil portion 30b exceeds 1,000°C, the heating coil portion 30b formed of such material fails to exhibit expected durability. For example, in the case where the heating coil portion 30b is formed of an Fe-Cr-Al alloy, the heating coil portion 30b must sufficiently endure the temperature of 1,000°C in the light of resistance to heat and oxidation of the alloy. However, when the heating coil portion 30b was actually manufactured from the alloy and subjected to a durability test at 1,000°C (a test method will be described later), the test confirmed a phenomenon that the surface of the heating coil portion 30b melted with resultant breakage of the heating coil portion 3b. Occurrence of such a phenomenon is unexpected, and the cause is unknown. The present inventors presumed the cause to be that a high temperature in excess of 1,000°C caused the insulating MgO powder 3d to react in a certain way with Fe or Ni contained in an alloy used to form the heating coil portion 30b, resulting in breakage of the heating coil portion 30b.

Summary of the invention:

[0005] An object of the present invention is to provide a glow plug that exhibits excellent durability at high temperature, particularly a high temperature in excess of 1,000°C.

[0006] To overcome the above stated problems, a glow plug according to claim 1 is provided. Further details, aspects and improvements of the invention are disclosed in the dependent claims, the figures and the description.

The present invention provides a glow plug comprising a sheathed heater and a tubular metallic shell, the sheathed heater comprising a tubular sheath having a closed distal end, a resistance wire coil disposed in the sheath and having at least a heating coil portion, an insulating MgO powder charged in the sheath, and a bar electrode having one end inserted into a rear end of the sheath in a sealed condition, the sheathed heater being inserted into a tubular hole of the metallic shell with a distal end portion of the sheath projecting outward from the metallic shell, wherein the heating coil portion comprises a coil base material and a coating layer, which covers the surface of the coil base material, and the coating layer is formed of Pt, Pd, Rh, or an alloy of two or more of Pt, Pd, and Rh.

[0007] On the basis of the present inventors' presumption that a high temperature in excess of 1,000°C probably caused the insulating MgO powder to react in a certain way with Fe or Ni contained in an alloy used to form the heating

coil portion, the coil base material of the heating coil portion is coated with a coating layer formed of Pt, Pd, Rh, or an alloy of two or more of Pt, Pd, and Rh so as to prevent direct contact between MgO and the coil base material, thereby yielding a glow plug that exhibits practically sufficient durability even at a high temperature in excess of 1,000°C.

Summary of the figures:

[0008]

FIG. 1: Vertical longitudinal view of a glow plug including a partially enlarged view.

FIG. 2: Vertical longitudinal view of a conventional glow plug including a partially enlarged view.

Emodiment of the invention:

[0009] An embodiment of the present invention will next be described with reference to the drawings. FIG. 1 is a vertical sectional view of a glow plug including a partially enlarged view.

[0010] As shown in FIG. 1, a glow plug 1 is composed substantially of a tubular metallic shell 2 and a sheathed heater 3, which extends axially through the metallic shell 2. The sheathed heater 3 is configured as follows: while a resistance wire coil 3b—which consists of a heating coil portion 30b located on the side toward the distal end of the resistance wire coil 3b and a control coil portion 300b located on the side toward the rear end of the resistance wire coil 3b—and a distal end portion of a bar electrode 3c are placed in a sheath 3a made of a heat-resisting metal, whose distal end is closed in a substantially hemispherical shape and whose rear end is open, the sheath 3a is filled with an insulating MgO powder 3d, and an insulating rubber packing 3e is interposed between the bar electrode 3c and the inner surface of an opening portion of the sheath 3a to thereby seal the opening. The bar electrode 3c is disposed such that its distal end is located in a longitudinally intermediate portion of the interior of the sheath 3a and electrically connected to the resistance wire coil 3b, whereas its rear end extends along the axis of the metallic shell 2 and projects outward therefrom. The resistance wire coil 3b is electrically connected to the inner surface of the closed distal end of the sheath 3a. Accordingly, the bar electrode 3c and the sheath 3a are electrically connected together via the resistance wire coil 3b.

[0011] The resistance wire coil 3b is configured such that the heating coil portion 30b and the control coil portion 300b are connected in series. Mainly the heating coil portion 30b generates heat to cause the distal end of the sheath 3a to glow, whereas the control coil portion 300b plays the role of suppressing current flowing to the heating coil portion 30b by virtue of its property that electric resistance increases rapidly with temperature. In order that its electric resistance sensitively reflects a change in temperature, a material having a high positive temperature-resistance coefficient, such as pure Fe or a Co-Ni alloy, is used to form the control coil portion 300b.

[0012] In order to endure high temperature, the heating coil portion 30b is configured as follows: an Fe-Cr-Al alloy or an Ni-Cr alloy, which has excellent resistance to oxidation and heat, is used as a coil base material 31b; and the surface of the coil base material 31b is coated with a coating layer 32b. The coating layer 32b is formed to be thin (preferred range of thickness: 0.2 to 0.5 μm, thickness in this embodiment: 0.3 μm) and uniform, from Pt (platinum), Pd (palladium), Rh (rhodium), or an alloy of two or more of Pt, Pd, and Rh through, for example, plating or vapor deposition. Since these metals used to form the coating layer 32b have high ductility and malleability, the coating layer 32b is unlikely to crack even when the resistance wire coil 3b undergoes a reduction in diameter in the process of swaging the sheath 3a. Incidentally, when the coating layer 32b cracks, the coil base material 31b and the insulating MgO powder 3d come into contact with each other through the crack, resulting in impaired durability at high temperature.

[0013] Durability Test: In order to confirm the effect of the present invention, five kinds of sheathed heaters 3 were fabricated as follows: an Fe-Cr-Al alloy (Fe: 66 wt.%; Cr: 26 wt.%; Al: 8 wt.%) was used as the coil base material 31b of the heating coil portion 30b; the control coil portion 300b was formed of a Co-Ni alloy (Co: 71 wt.%; Ni: 25 wt.%; Fe: 4 wt.%); and the coating layer 32b of the heating coil portion 30b was varied as No. 1 (unplated), No. 2 (Ni plating), No. 3 (Pt plating), No. 4 (Rh plating), and No. 5 (Pd plating). By use of the sheathed heaters 3, the glow plugs 1 as shown in FIG. 1 were manufactured and subjected to a durability test. The test results are shown in Table 1. In the durability test, the glow plugs 1 were continuously subjected to test cycles, each cycle consisting of application of 11 Vdc for 10 sec → application of 13 Vdc for 300 sec → OFF for 60 sec. In the durability test, the maximum temperature of the heating coil portion 30b reaches about 1,100°C.

[0014]Table 1:

No.	Coil base material of heating coil portion	Coating layer (plating)	Control coil portion	Breakage of wire	Performance deterioration	Durability
1	Fe-Cr-Al	Unplated	Co-Ni	x	x	x
2	Fe-Cr-Al	Ni	Co-Ni	Δ	x	x
3	Fe-Cr-Al	Pt	Co-Ni	o	o	o
4	Fe-Cr-Al	Rh	Co-Ni	o	o	o
5	Fe-Cr-Al	Pd	Co-Ni	o	o	o

[0014] In the "Breakage of wire" column of Table 1, "x" denotes that complete wire breakage was observed; "Δ" denotes that an indication of wire breakage was observed; and "o" denotes that no indication of wire breakage was observed.

The symbol "x" in the "Performance deterioration" column denotes that, after subjection to a predetermined number of test cycles (5,000 cycles or more), heating temperature dropped by 100°C or more as compared with that measured at the beginning of the test.

The "Durability" column shows overall evaluation based on the results of "Breakage of wire " and "Performance deterioration." In the "Durability" column, "x" denotes that a problem exists in terms of durability, and "o" denotes that no problem exists in terms of durability.

[0015] As is apparent from the results shown in Table 1, glow plugs Nos. 3 to 5, which correspond to embodiments of the present invention, exhibit excellent durability as compared with glow plugs Nos. 1 and 2. Notably, in the case of glow plug No. 2, in which the coil base material 31b is plated with Ni, performance deterioration is brought about conceivably as a result of alloying of Ni and the coil base material 31b.

[0016] Although the present invention has been described with reference to an embodiment, the present invention is not limited thereto. For example, the embodiment is described while mentioning the self-control-type glow plug 1; however, the present invention is also applicable to a glow plug that does not include the control coil portion 300b; i. e., to a glow plug in which the entire resistance wire coil 3b serves as the heating coil portion 30b.

The gist of the present invention resides in the structure of the heating coil portion 30b. Therefore, no particular limitation is imposed on the structure of the control coil portion 300b.

[0017] Effect of the Invention: In view of a phenomenon that at a high temperature in excess of 1,000°C, a heating coil portion of a resistance wire coil fails to exhibit expected durability even though a material used to form the heating coil portion has sufficient resistance to heat and oxidation, the present inventors assumed the cause and devised a structure of coating a coil base material of the heating coil portion with a coating layer, thereby obtaining a glow plug that exhibits practically sufficient durability even at a high temperature in excess of 1,000°C. Therefore, the present invention is highly useful in terms of implementation of a glow plug that exhibits excellent durability at high temperature, particularly a high temperature in excess of 1,000°C.

Reference Numerals of the Figures:

[0018]

1: glow plug
2: metallic shell
3: sheathed heater
3a: sheath
3b: resistance wire coil
30b: heating coil portion
31b: coil base material
32b: coating layer
3c: bar electrode
3d: insulating powder

Claims

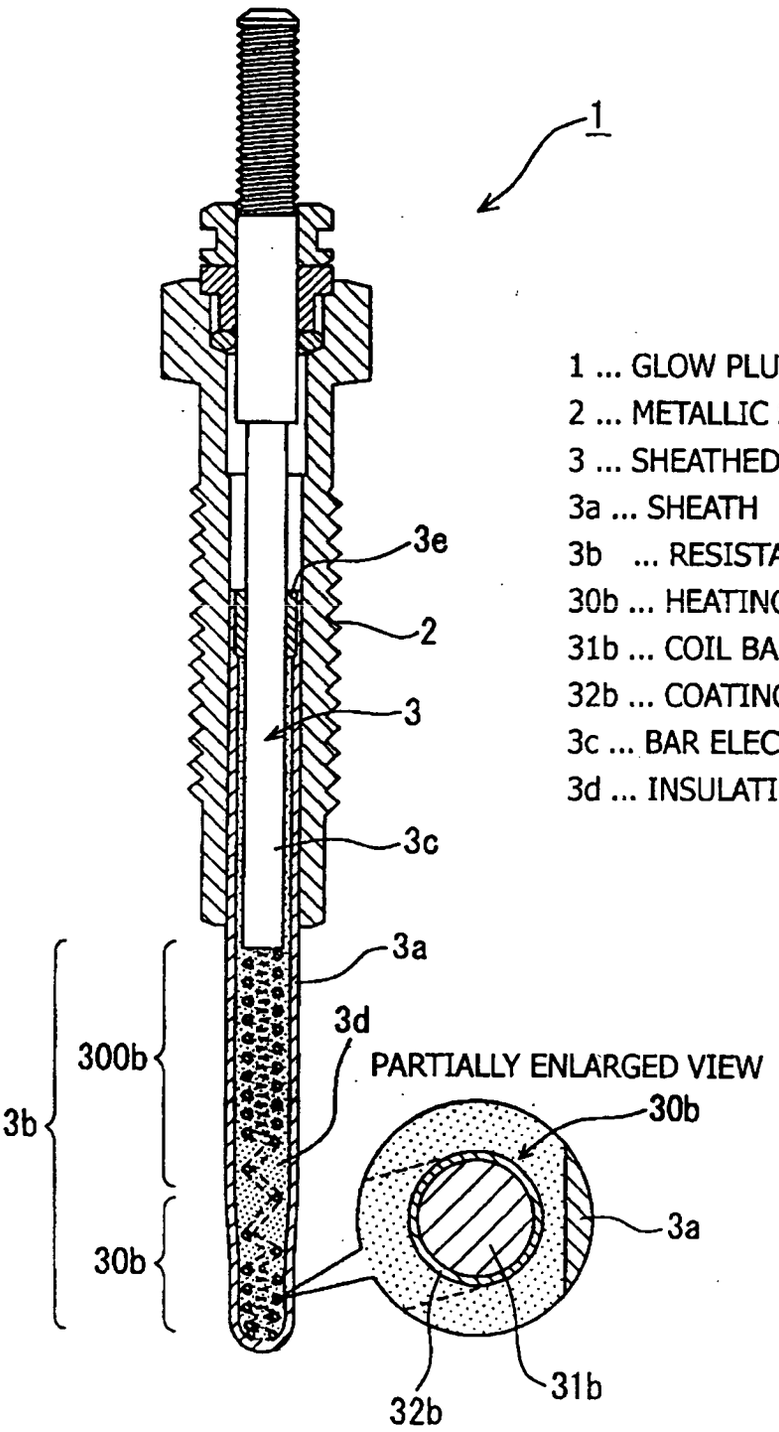
1. A glow plug comprising a sheathed heater and a tubular metallic shell, the sheathed heater comprising a tubular sheath having a closed distal end, a resistance wire coil disposed in the sheath and having at least a heating coil portion, an insulating MgO powder charged in the sheath, and a bar electrode having one end inserted into a rear end of the sheath in a sealed condition, the sheathed heater being inserted into a tubular hole of the metallic shell with a distal end portion of the sheath projecting outward from the metallic shell,
   wherein the heating coil portion comprises a coil base material and a coating layer, which covers the surface of the coil base material, and the coating layer is formed of Pt, Pd, Rh, or an alloy of two or more of Pt, Pd, and Rh.

2. A glow plug according to claim 1, wherein the coil base material of the heating coil portion is an Fe-Cr-Al alloy.

3. A glow plug according to any of claim 1 or 2,
   wherein the coating layer has a thickness of 0.2 μm to 0.5 μm.

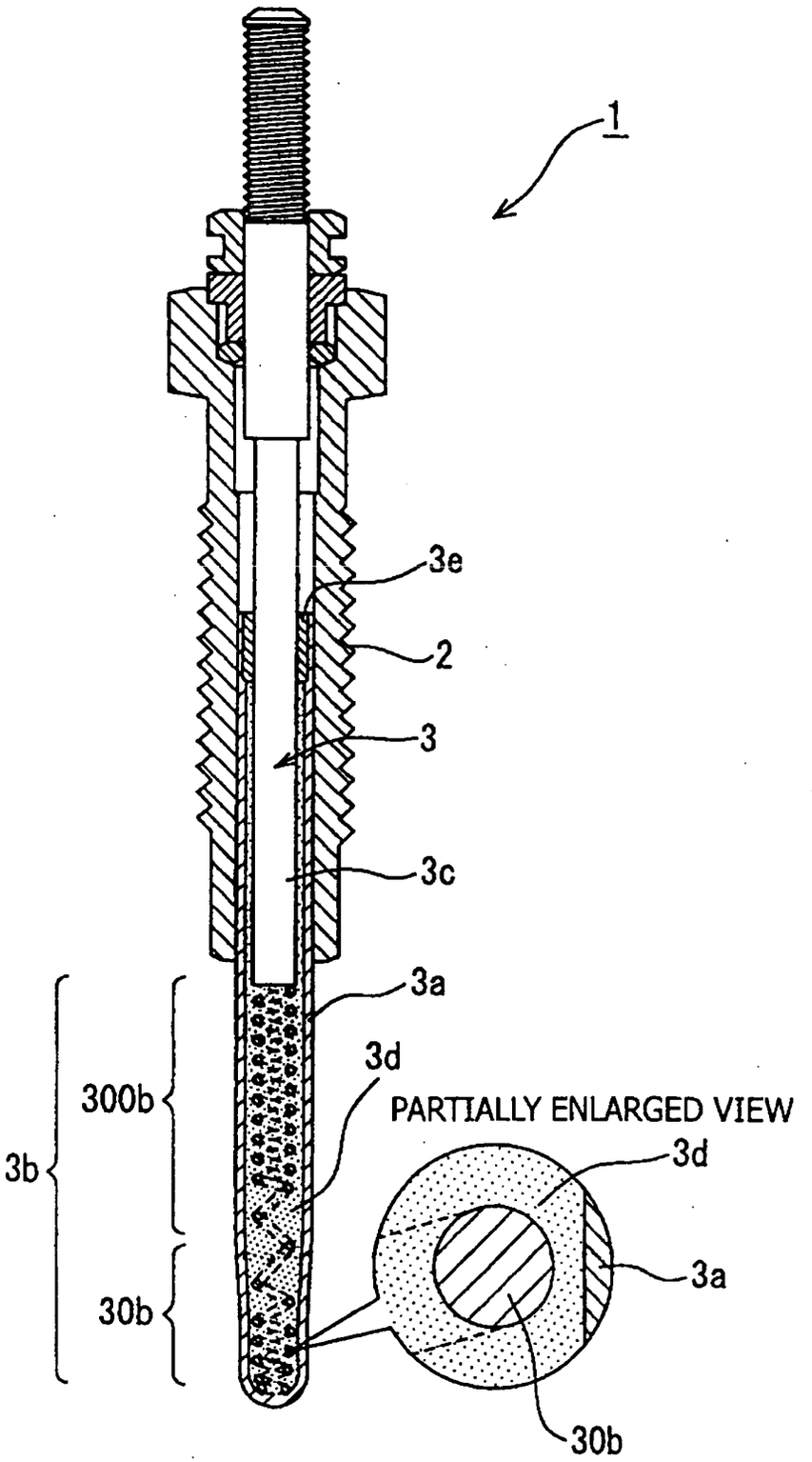
4. A glow plug according to any of claims 1 to 3,
   wherein the coating layer includes Pt.

Fig. 1



1 ... GLOW PLUG
2 ... METALLIC SHELL
3 ... SHEATHED HEATER
3a ... SHEATH
3b ... RESISTANCE WIRE COIL
30b ... HEATING COIL PORTION
31b ... COIL BASE MATERIAL
32b ... COATING LAYER
3c ... BAR ELECTRODE
3d ... INSULATING POWDER

Fig. 2



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EUROPEAN SEARCH REPORT

Application Number
EP 04 00 4740

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
MUNICH	7 June 2004	Ulivieri, E

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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 04 00 4740

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