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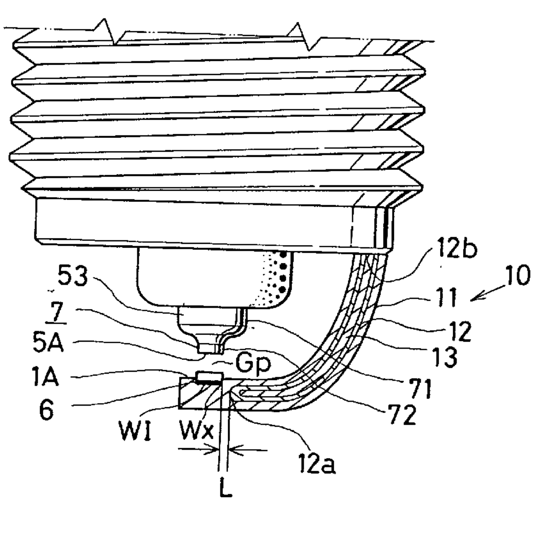
(54) Spark plug with a platinum tip on its outer electrode.

(57) In a spark plug which has a center electrode disposed in a metallic shell through an insulator so that a front end of the center electrode forms a spark gap with an outer electrode extended from the metallic shell, the outer electrode has a heat-conductive core metal cladded by a matrix metal which is made from nickel-based alloy containing 10 ~ 20 wt% chronium. A platinum tip is welded to the outer electrode so that a spaced distance between a circumferential edge of the welded portion and a front end of the core metal falls within a range from 0.0 mm to 2.0 mm.

Fig. 2



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This invention relates to a spark plug having a platinum tip welded to its outer electrode, and particularly concerns an improvement intended to avoid deterioration of the welded portion between the tip and the outer electrode.

With the recent demand for cleaner emission gas and enhanced fuel consumption from internal combustion engines, it has been needed to run the engine with a leaner mixture of gasoline. With higher temperatures in the combustion chamber the outer electrode of the spark plug tends to be exposed to higher temperatures.

With the further demand for continuous running of engines for more than 100,000 Km without replacing the spark plugs, it has been suggested that the outer electrode be made of a copper core cladded by a nickel-alloy matrix, while platinum tips are welded to the opposing ends of both outer and center electrodes so as to improve oxidation and corrosion-resistance.

Compared to the center electrode, the outer electrode, however, is exposed to higher ambient temperature to such a degree that the platinum tip tends to fall off the outer electrode at the welded portion.

In an extension-type spark plug in which a firing end of the spark plug is extended into the combustion chamber, the outer electrode is all the more exposed to higher ambient temperature, and successively cooled by newly introduced mixture of gasoline.

As a result, a greater intensity of thermal stress occurs at the welded portion between the tip and the outer electrode so that the tip is liable to fall off the outer electrode.

Therefore, it is an object of the invention to provide a spark plug having a platinum tip welded to an outer electrode which is capable of effectively reducing the effect of thermal stress between the platinum tip and the outer electrode, thus contributing to an extended period of service life with a relatively simple structure.

According to the present invention, there is provided a spark plug comprising a center electrode disposed within an insulator in a metallic shell so that the front end of the center electrode forms a spark gap with an outer electrode extending from the metallic shell, and a platinum tip welded to the outer electrode so as to oppose the front end of the center electrode;

the outer electrode comprising a heat-conductive core metal cladded by a matrix metal which is made from nickel-based alloy containing 10 - 20% by weight of chromium;

the tip being placed so that the distance between a circumferential edge of the weld between the outer electrode and the tip and the front end of the core metal is between 0.0 mm to 2.0 mm.

Such is the dimensional arrangement between the platinum tip and the core metal that a significant amount of heat is smoothly dissipated from a front end of the outer electrode to the metallic shell by way of the core metal. Thus prevents the temperature of the front end of the outer electrode from rising excessively, and reduces the thermal stress occurring at the welded portion between the tip and the outer electrode, and at the same time, reduces oxidation of the welded portion so as to prevent the tip from falling off the outer electrode.

When the welded portion is positioned so as partly to overlap with the front end of the core metal, the core metal is liable to be softened, and the outer electrode to deform at the time of welding the tip to the outer electrode.

Meanwhile, the platinum tip begins to fall off the outer electrode when the spaced distance exceeds 2.0 mm. Hence the spaced distance is determined to fall within the range from 0.0 mm to 2.0 mm.

The invention will be further understood from,the following description, when taken together with the attached drawings which are given by way of example only, and in which:

Fig. 1 is a sectional view of a spark plug.

Fig. 2 is an enlarged longitudinal cross sectional view of an outer electrode showing the front end portion of the spark plug;

Fig. 3 is a graph showing how corrosion (S) changes with operating time (T) and a spaced distance (L); and

Fig. 3a is a partly broken view of the outer electrode to define an axial length (A) of a platinum tip and an axial length (B) of a welded portion.

Referring to a spark plug shown in Fig. 1, there is shown a cylindrical metallic shell 2, to a front end of which a L-shaped outer electrode 1 is welded. Within the metallic shell 2, a tubular insulator 3 is placed whose inner space acts as an axial bore 31. Within the axial bore 31 of the insulator 3, a middle axis 4 is placed whose rear and has a terminal 41 to which a high tension cord of an ignition circuit (not shown) is to be connected. To a front end of the middle axis 4, a glass sealant resistor 42 and a center electrode 5 are in turn connected in linear relationship with each other. A front end 5A of the center electrode 5 extends from the metallic shell 2 to oppose a front end 1A of the outer electrode 1 so as to form a spark gap (Gp) therebetween.

In this instance, the spark plug is an extension-type one in which the front end 5A of the center electrode 5 extends from the metallic shell 2 by 1.5 ~ 15.0 mm so that the front end 5A projects into a combustion chamber (Ch) by 3.0 ~ 17.0 mm when the spark plug is mounted on an internal combustion engine.

The outer electrode 1 consists a composite base metal 10 having a heat-conductive core metal 12 cladded by a nickel-alloyed matrix 11 which contains 10 ~ 20 wt% chrominum. To the front end 1A of the nickel-alloyed matrix 11, a column platinum tip 6 is welded at a welded portion (Wl) in a manner to oppose the front end 5A of the center electrode 5. It is noted that the tip 6 may contain 20 wt% iridium (Ir).

The nickel-alloyed matrix 11 increases its oxidation-resistance with an increased addition of chromi um, while inviting an increased hardness and reduced thermal conductivity. The nickel-alloyed matrix 11 containing chromi um less than 10 wt% causes to deteriorate its oxidation-resistance. Hence the chromi um content is 10 ~ 20 wt%.

The core metal 12 is made from copper, silver, copper-based alloy or silver-based alloy, and having a front end 12a and a rear end 12b, the latter of which is placed in heat-transferable contact relationship with a front end of the metallic shell 2.

In order to provide the composite base metal 10 with three-layer structure, the core metal 12 clads an innermost core 13 which is made of pure nickel or pure iron. Thus contributes to improving a weld-intensity of the outer electrode 1 to the metallic shell 2, and at the same time, preventing the deformation of the outer electrode 1 which arises from the heat-cool cycle of the internal combustion engine.

The welded portion (Wl) of the tip 6 is arranged to terminate slightly short of the core metal 12, so that a spaced distance (L) between a circumferential edge (Wx) of the welded portion (Wl) and the front end 12a of the core metal 12 falls within a range from 0.0 mm to 2.0 mm as shown in Fig. 2.

The nickel-alloyed matrix 11, which contains 10 ~ 20 wt% chronium, is somewhat inferior in thermal conductivity but superior in both high-temperature strength and oxidation -resistance compared to a nickel-alloyed outer electrode which usually contains more than 90 wt% nickel. In order to compensate for the insufficient thermal conductivity of the nickel-alloyed matrix 11, the front end 12a of the core metal 12 is extended toward the circumferential edge (Wx) of the welded portion (Wl) within a range from 0.0 mm to 2.0 mm. The spaced distance (L) makes it possible to prevent an excessive temperature rise of the front end 1A of the outer electrode 1, and thus prevents increased thermal stress from occurring at the welded portion (Wl), keeping the tip 6 in place.

In assembling the spark plug, the straight-type outer electrode is firstly welded to the metallic shell 2. Then, the insulator 3 is placed within the metallic shell 2. Before bending the outer electrode 1 into L-shaped configuration, the tip 6 is secured to the outer electrode 1 by means of resistance welding. The copper or silver core 12 may be softended and buckled during the resistance welding when the circumferential edge (Wx) of the welded portion (Wl) partly overlaps with the front end 12a of the core metal 12. Hence the lower limit of the spaced distance (L) is determined to be 0.0 mm, preventing an overlapping relationship between the circumferential edge (Wx) of the welded portion (Wl) and the front end 12a of the core metal 12.

On the other hand, the center electrode 5 consists a composite base metal 50 having a copper core 51 cladded by a nickel-alloyed matrix 52 which contains more than 90 wt% nickel. To a front end of the composite base metal 50. A nickel-alloyed layer 53 which contains 20 ~ 25 wt% chronium is secured by means of resistance welding. To a front end of the nickel-alloyed layer 53, a platinum tip 7 is secured by means of resistance welding. The platinum tip 7 has a diameter-increased portion 71 welded to the nickel-alloyed layer 53, and a diameter-reduced portion 72 which opposes the platinum tip 6 across the spark gap (Gp).

It is noted that outer configuration of the nickel-alloyed layer 53 and the platinum tip 7 may be shaped after carrying out the resistance welding in order to prevent their unfavorable deformations during the welding operation.

It is noted that the nickel-alloyed layer 53 may be left out, and the platinum tip 7 may be welded directly to a front end of the diameter-reduced portion of the nickel-alloyed matrix 52 instead of the nickel-alloyed layer 53.

Fig. 3 shows a graph showing how corrosion (S) of the welded portion (Wl) changes with operating time (T) and the spaced distance (L) after carrying out an endurance experiment with the spark plug mounted on a four-cylinder, 2000 cc, four-cycle internal combustion engine which is alternately operated idling and full throttle at the heat-cool cycle process.

In this experiment, Fig. 3a shows a partly broken outer electrode 1 to define an axial length (A) of the platinum tip 6 and an axial length (B) of the welded portion. (Wl). The amount of corrosion (S) of the welded portion (Wl) is expressed by (A-B)/A for the purpose of convenience.

As a result, it is found that a rapid corrosion occurs at the welded portion (Wl) in the cases when the spaced distance is 5.0 mm or 3.0 mm with the innermost core 13 provided in the core metal 12 to form the three-layer structure, and in the case when no core metal is provided.

It is also found that only small amount of corrosion (S) occurs at the welded portion (Wl), but the outer electrode is subjected to an unfavorable deformation (the spark gap widens) when the spaced distance is 0.0 mm with no innermost core provided in the core metal 12 to merely form a two-layer structure. Therefore it is desirable to exclude the case when the spaced distance is 0.0 mm upon putting the invention into practical use.

It is, however, understood that only small amount of corrosion (S) occurs at the welded portion (Wl) when the spaced distance is kept within the range from 0.0 mm to 2.0 mm.

It is appreciated that the invention is not restricted to the extension-type spark plug in which the center electrode 5 projects into the combustion chamber (Ch).

While the invention has been described with reference to the specific embodiments, it is understood that this description is not to be construed in a limiting sense in as much as various modifications and additions to the specific embodiments may be made by skilled artisan without departing from the scope of the invention as defined in the appended claims.

Claims

1. A spark plug comprising a center electrode disposed within an insulator in a metallic shell so that the front end of the center electrode forms a spark gap with an outer electrode extending from the metallic shell, and a platinum tip welded to the outer electrode so as to oppose the front end of the center electrode;

    the outer electrode comprising a heat-conductive core metal cladded by a matrix metal which is made from nickel-based alloy containing 10 ~ 20% by weight of chromium;

    the tip being placed so that the distance between a circumferential edge of the weld between the outer electrode and the tip and the front end of the core metal is between 0.0 mm to 2.0 mm.

2. A spark plug according to claim 1, wherein the core metal is made of one of the following: silver, copper, a silver-based alloy or a copper-based alloy.

3. A spark plug according to claim 1 or 2, wherein an innermost core is provided to be cladded by the core metal, the innermost core being made of substantially pure nickel or substantially pure iron.

4. An internal combustion engine comprising a spark plug according to any preceding claim.

Fig. 1

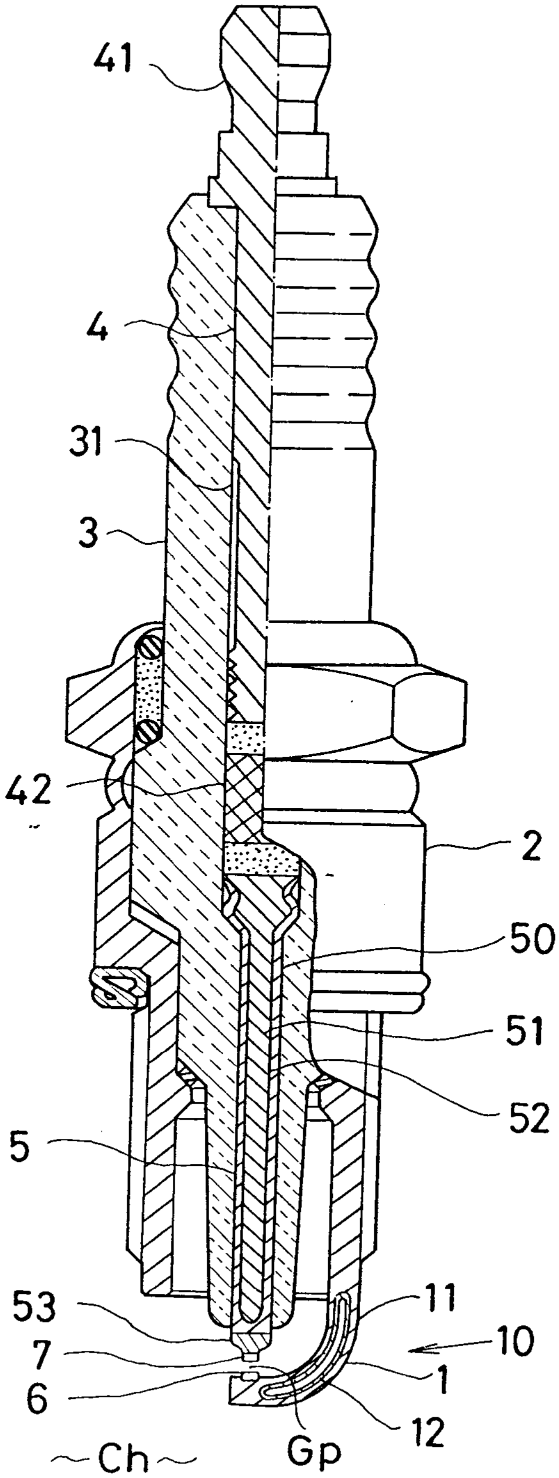


Fig. 2

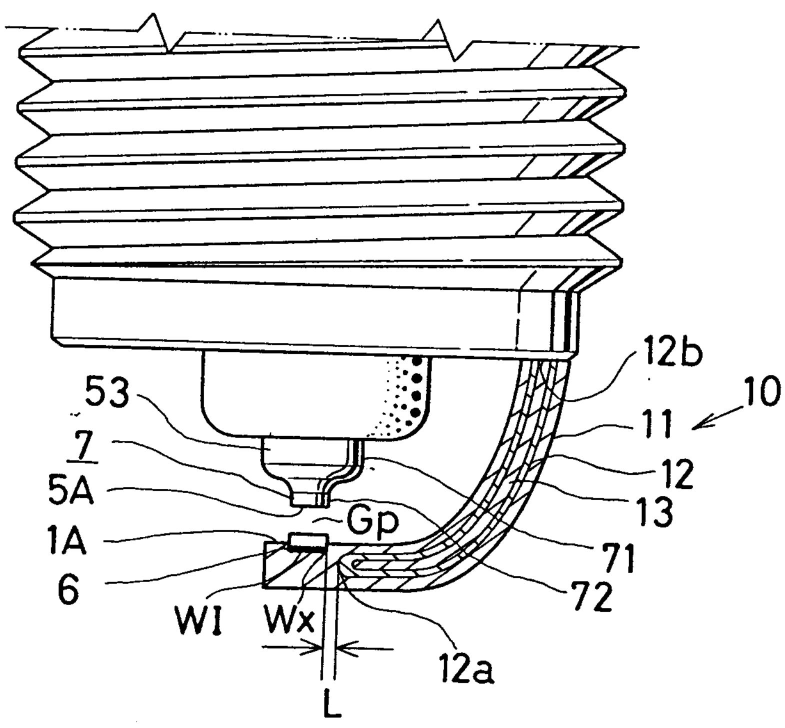


Fig. 3

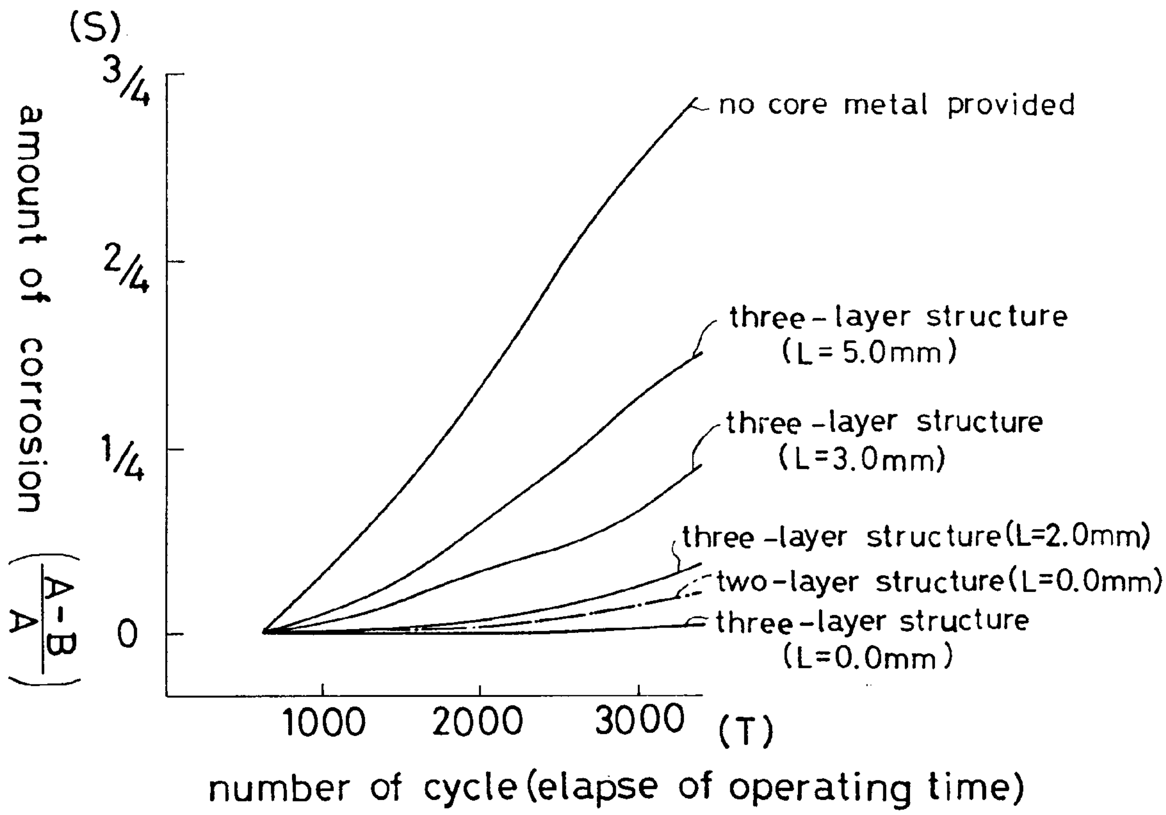
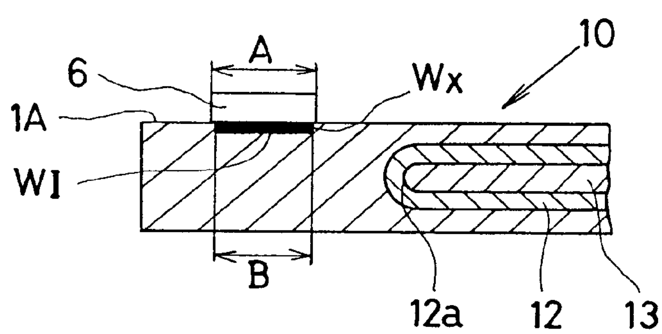

(S)
3/4
2/4
1/4
0
amount of corrosion (A-B / A)
no core metal provided
three-layer structure (L=5.0mm)
three-layer structure (L=3.0mm)
three-layer structure(L=2.0mm)
two-layer structure(L=0.0mm)
three-layer structure (L=0.0mm)
1000
2000
3000
(T)
number of cycle(elapse of operating time)

Fig. 3a


A
6
10
Wx
1A
WI
B
12a
12
13