April 14, 1959 D. K. HANINK 2,881,750

VALVE

Filed March 29, 1956

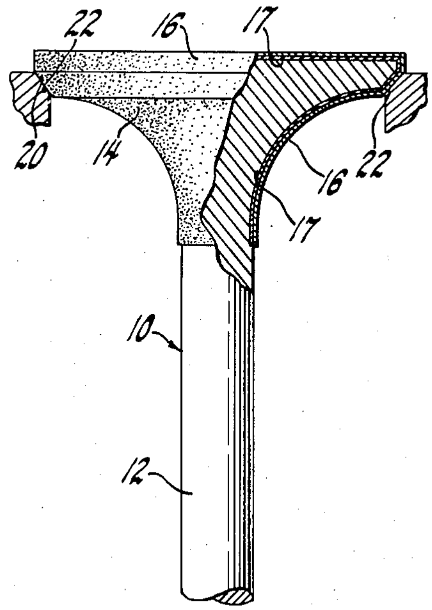


Fig. 1

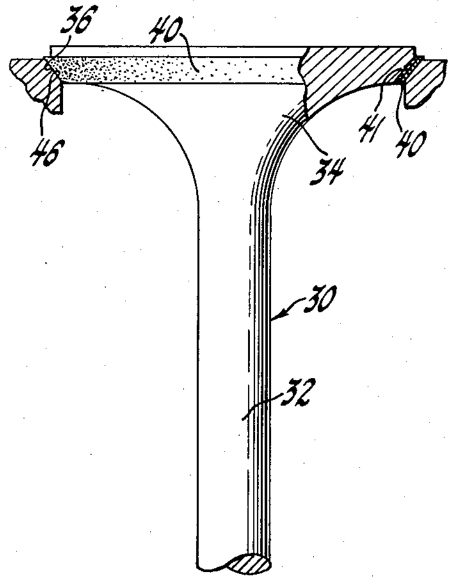


Fig. 2

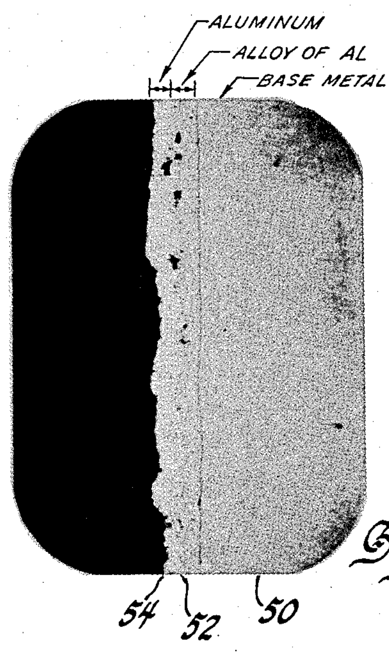


Fig. 3

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2,881,750

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# VALVE

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Application March 29, 1956, Serial No. 574,875

13 Claims. (Cl. 123—188)

This application is a continuation-in-part of my copending application Serial No. 364,673, filed June 29, 1953, and now abandoned.

This invention relates to valves and is more particularly concerned with valves for internal combustion engines.

Valves for internal combustion engines have been subject to rapid oxidation and high temperature corrosion caused by hot combustion gases. This condition has become more pronounced as compression ratios have been increased. The gases which result from burning leaded gasolines in particular are extremely detrimental and greatly shorten the valve life in such engines. The valve failure may occur because of high temperature corrosion of the valve seating face or because of corrosion of the stem immediately beneath the valve head. Severe corrosion of this stem results in its necking down to the point where the stem will fracture.

The primary object of the present invention is to provide a valve for an internal combustion engine having a greatly increased operating life. Other objects and advantages of the invention will become more apparent as the description proceeds.

In accordance with the present invention there is provided a valve for internal combustion engines having at or adjacent its surface, at least at the valve seat facing portion thereof, a thin layer of an alloy of aluminum or aluminum base alloy and the base metal of the valve. For best results the valve also has an extremely thin layer of aluminum or aluminum base alloy on said alloy layer. I have found that the layer or layers should be extremely thin to provide valves having the required characteristics such that the surface alloy layer does not spall or flake off.

The alloying of the surface portion of the valve with aluminum or aluminum base alloy may be carried out in any desired manner. One method is to apply molten aluminum or aluminum base alloy to the valve under such conditions that the aluminum will form an alloy with the valve material and result in the desired requisite thinness. One very satisfactory method is to apply the aluminum or aluminum base alloy in accordance with any of the procedures described in Patent 2,569,097, owned by the assignee of the present invention. An especially advantageous method comprises preheating the valve to a temperature of about 1300° F. to 1325° F. in a fused salt bath consisting of 37% to 57% KCl, 25 to 45% NaCl, 8% to 20% $Na_3AlF_6$, 0.5% to 12% $AlF_3$ then immersing the valve in a molten bath of aluminum or aluminum base alloy at a temperature of about 1300° F. for a short period of time, not over about ten seconds in most instances, thereafter removing the valve from the aluminum, then rinsing for a short time of not more than fifteen seconds in the fluxing salt, and finally removing excess coating material as by means of an air blast, rapid rotation of the valve or by vibrating the valve rapidly. The valve as thus treated has an extremely thin and uniform coating of aluminum bonded to the base metal by an intermediate extremely thin and uniform layer of an alloy of aluminum with the base metal.



Other satisfactory methods of coating the valve and forming the alloy of aluminum therewith are disclosed in copending application of Hanink, Shoudy, Jr., and Thomson, Serial No. 459,093, filed September 29, 1954, and owned by the assignee of the present invention.

In processing the valve, the base metal from which the valve is made is machined substantially to final dimensions before the aluminum alloying takes place. Since the preferred method results in an extremely thin and uniform coating of aluminum on the valve it is unnecessary to grind or otherwise remove any of the aluminum coating prior to use of the valve. However, where a thicker coating of aluminum is produced during the coating step, the valve seat facing may be honed or otherwise processed to remove some or all of the aluminum coating overlay without materially affecting the intermediate alloy layer.

The surfaces of the valve to be coated are preferably cleaned prior to the aluminum coating and alloying operation. One satisfactory method is to clean the valves in a molten electrolytic caustic salt (such for example as a commercially available product called Kolene) at 900° F. The parts then may be water washed and thereafter preferably further cleaned by acid pickling. A suitable acid pickling bath is an aqueous solution containing about 2.0% hydrofluoric acid, 7.0% sulphuric acid, and 10% nitric acid. In some cases the valves may only require a vapor degreasing treatment in chlorinated solvent prior to the aluminum coating and alloying operation. Mechanical cleaning methods, such as grit blasting, sand blasting, etc., may be employed in some cases to supplement the chemical cleaning treatments. In addition to forming a clean surface for adherence of the coating material, the cleaning treatments show up any cracks or other surface defects in the valves.

After the valve has been cleaned, the portion thereof on which it is desired that no coating be applied may be treated with a suitable stop-off coating to prevent the aluminum from bonding to or alloying with the base metal at such surfaces. A suitable stop-off material for this purpose is a sodium silicate solution. A typical solution is an aqueous solution containing 20% to 50% sodium silicate. If additional strength and density of stop-off are desired, a ceramic such as zirconium oxide may be added to the sodium silicate solution. The preferred combination is 1 part by volume ceramic to 1 part solution.

The invention is applicable to all valves which are subjected to hot combustion gases, typical examples being intake and exhaust valves of the poppet type, flapper valves, butterfly valves and the like. The base metal of which the valve is formed may be any suitable valve material and especially any material of the type or types heretofore employed for valves. Typical and illustrative examples of valve materials are the following:

*Example 1*

| | Percent |
|---|---|
| Carbon | 0.80 |
| Manganese | 0.4 |
| Silicon | 2.25 |
| Chromium | 20 |
| Nickel | 1.3 |

Balance substantially all iron.

*Example 2*

| | Percent |
|---|---|
| Carbon | 0.45 |
| Manganese | 1.00 |
| Silicon (max.) | 1.00 |
| Chromium | 23.75 |
| Nickel | 4.75 |
| Molybdenum | 2.75 |

Balance substantially all iron.

*Example 3*

| | Percent |
|---|---|
| Carbon | 0.45 |
| Manganese | 0.40 |
| Silicon | 3.25 |
| Chromium | 8.50 |
| Balance iron. | |

*Example 4*

| | Percent |
|---|---|
| Carbon | .20 |
| Manganese | 1.40 |
| Silicon | 0.80 |
| Chromium | 21.00 |
| Nickel | 12.00 |
| Balance iron. | |

*Example 5*

| | Percent |
|---|---|
| Carbon | 0.45 |
| Manganese (max.) | 0.70 |
| Silicon | 0.55 |
| Chromium | 14.00 |
| Nickel | 14.00 |
| Molybdenum | 0.35 |
| Tungsten | 2.50 |
| Balance iron. | |

*Example 6*

| | Percent |
|---|---|
| Carbon | 0.40 |
| Manganese | 1.0 |
| Silicon | 3.0 |
| Chromium | 19.0 |
| Nickel | 8.0 |
| Balance iron. | |

*Example 7*

| | Percent |
|---|---|
| Carbon | .04 |
| Manganese | .50 |
| Silicon | .40 |
| Columbium | 1.00 |
| Aluminum | .70 |
| Iron | 7.00 |
| Chromium | 15.00 |
| Balance nickel. | |

*Example 8*

| | Percent |
|---|---|
| Carbon | 1.0 |
| Manganese | .25 |
| Silicon | 1.25 |
| Chromium | 28.00 |
| Tungsten | 4.50 |
| Iron | 2.00 |
| Balance cobalt. | |

The alloy of aluminum with the valve material should in all cases be extremely thin. In general, the layer of this alloy will have a thickness within the range of from 0.00005 inch to 0.0015 inch and the aluminum have a thickness within the range of from 0.00 inch to 0.004 inch. A very satisfactory alloy layer is one having a thickness within the range of from 0.0002 inch to 0.001 inch. In some applications, it is of further advantage to have a minimum thickness of the alloy layer of 0.0005 inch. It is presently preferred, especially with valve steels of the type of Example 1 above, that the layer of the alloy of aluminum therewith be not over .001 inch in thickness. Tests indicate that exhaust valves of the poppet type made from the valve steel of Example 1 and having the thin alloy layer and the thin aluminum layer of this invention have no indication of burning after operation in autobiles for more than 20,000 miles under accelerated test conditions, while similar valves without the thin aluminum alloy layer and thin aluminum layer burn in less than 10,000 miles under similar test conditions.

The coating material may be either aluminum or any known aluminum base alloy. By "aluminum base alloy" is meant an alloy of aluminum which contains about 80% or more of aluminum. Where the word "aluminum" is used in the claims to refer to the coating material, it is intended to include not only pure aluminum, or commercially pure aluminum, but also the aluminum base alloys containing about 80% or more of aluminum.



Reference is herewith made to the accompanying drawings in which:

Figure 1 is a view partially in section of a poppet valve having a coating on its head and neck portions, the valve being in closed position on a valve seat.

Figure 2 is a view generally similar to Figure 1 and showing a poppet valve with a coating only on the valve seat facing portion of the valve.

Figure 3 is a photomicrograph showing a portion of the base metal of the valve, a layer of an alloy of aluminum with the valve metal and a layer of aluminum on the alloy layer.

In Figure 1 there is shown a poppet valve indicated generally by **10** and having a stem **12** and head **14**. The entire head and upper portion of the valve stem which in engine assembly will not contact valve guide are provided with a coating **16** of aluminum or aluminum base alloy and an intermediate alloy layer **17** of aluminum and the base metal of the valve. The thicknesses of the coating **16** and alloy layer **17** are exaggerated in the drawing. The valve of Figure 1 is shown in closed position on the valve seat **20**, the valve having a tapered valve seat facing **22** in engagement with the valve seat. Figure 2 shows a valve **30** having a stem **32** and a head **34**. In the construction shown in Figure 2 only the tapered valve seat facing portion **36** of the valve is provided with a coating **40** of aluminum or aluminum base alloy and an intermediate layer **41** of aluminum and the base metal of the valve. The thicknesses of the coating **40** and the alloy layer **41** are exaggerated in the drawing. In Figure 2 the valve is shown in closed position with the tapered valve seat facing **36** contacting the corresponding tapered surface **46** of the valve seat. In the photomicrograph shown in Figure 3, the base metal of the valve is indicated at **50**, while **52** indicates the alloy of aluminum with the base metal and **54** the outermost layer of aluminum. The magnification of the photomicrograph of Figure 3 has been measured at 200×.

The present invention results in valves having greatly increased life and at a relatively small cost. The valve is one of high quality in which there is provided a continuous chemical bond at the interface of the coating metal and base metal of the valve. The process provides a uniform aluminum coating on the appropriate surfaces of the valve and the thickness of this coating can be closely regulated. In turn, the thickness of the intermediate iron-aluminum (or other alloy of aluminum and base metal of the valve) may be controlled. It is important that the layer of intermediate alloy be thin as hereinbefore described to prevent spalling or flaking. The thin alloy layers have demonstrated superior yielding characteristics when the valve seating face is "pounded in" during service. Small depressions in the seating face of the valve caused by engine deposits which become lodged between the valve seating face and valve seat remain protected by the surface alloy layer.

While this invention has been described by reference to certain preferred embodiments and specific examples of preferred materials and conditions, it will be understood the invention is not to be limited thereby as numerous changes and modifications will be apparent to those skilled in the art without departing from the spirit and principles of the invention.

I claim:

1. A valve having a surface portion coated with a thin layer of aluminum, said aluminum being bonded to the base material of the valve with an alloy of aluminum with said base material having a thickness between 0.00005" and 0.0015".

2. A valve formed of a ferrous base material having a surface portion coated with a thin layer of aluminum, said aluminum being bonded to said ferrous base material with an alloy of aluminum with said ferrous base material having a thickness between 0.00005" and 0.0015".

3. A valve comprising a ferrous base material formed in the shape of a poppet valve, a thin aluminum coating on the head of said valve, and a layer of iron-aluminum alloy intermediate said ferrous base material and said aluminum coating and having a thickness between 0.00005" and 0.0015".

4. A valve comprising a ferrous base material formed in the shape of a poppet valve, a thin aluminum coating on the valve seat facing of said valve, and an intermediate layer of an iron-aluminum alloy having a thickness between 0.00005" and 0.0015".

5. A valve formed of a ferrous base material, a layer having a thickness between 0.00005" and 0.0015" of an alloy of aluminum with said ferrous base material, and an extremely thin layer of aluminum not in excess of 0.004" on said alloy layer.

6. A poppet valve comprising a ferrous base material in poppet valve form having a valve seat facing portion and an adherent layer having a thickness between 0.00005" and 0.001" of an alloy of aluminum with the ferrous base metal at the valve seat facing portion of said valve.

7. A valve comprising a ferrous base material in poppet valve form having a valve seat facing portion, an adherent layer of an alloy of aluminum with the ferrous metal at the valve seat facing portion of said valve having a thickness of 0.00005" to 0.001" and an extremely thin layer of aluminum having a thickness not in excess of 0.004" bonded to said alloy layer.

8. A valve having a valve seat facing portion and having an adherent layer of an alloy of aluminum with the base metal of the valve at the valve seat facing portion of the valve, said alloy having a thickness within the range of 0.00005" and 0.0015".



9. A valve comprising a ferrous base material in poppet valve form, having an adherent layer of an alloy of aluminum with the ferrous metal on the valve seat facing portion of said valve, having a thickness within the range of about 0.0002" to 0.001" and a very thin layer of aluminum having a thickness not in excess of 0.004" bonded to said alloy layer.

10. A valve comprising a ferrous base material in poppet valve form, having an adherent layer of an alloy of aluminum with the ferrous metal on the valve seat facing portion of said valve, having a thickness within the range of about 0.0005" to 0.001" and an extremely thin layer of aluminum having a thickness not in excess of 0.004" bonded to said alloy layer.

11. A poppet valve having an adherent layer of an alloy of aluminum with the valve seat facing portion of said valve, having a thickness within the range of about 0.0002" to 0.001".

12. A poppet valve having an adherent layer of an alloy of aluminum with the valve seat facing portion of said valve, having a thickness within the range of about 0.0005" to 0.001".

13. A poppet valve formed of ferrous-base material having a valve seat facing portion, an adherent layer of an alloy of aluminum with the ferrous metal in the valve seat facing portion having a thickness within the range of 0.00005" to 0.0015" and an extremely thin layer of aluminum having a thickness not over 0.004" adherently bonded to said alloy layer.


**References Cited** in the file of this patent

FOREIGN PATENTS

| | | |
|---|---|---|
| 577,427 | Great Britain | May 17, 1946 |
| 620,165 | Great Britain | Mar. 21, 1949 |

OTHER REFERENCES

Publication: "Mechanical Engineers Handbook," L. S. Marks, fourth edition, pages 685 and 686.