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INT CL **C23C, F01L**
Other: **EPODOC, WPI**

(54) Title of the Invention: **Poppet valve**
Abstract Title: **Poppet valve fillet surface with increased thermal resistance**

(57) A poppet valve for a combustion engine has valve body 6 comprising a valve stem 2, a valve head 3 with a valve combustion face 4, and a valve fillet 5 interconnecting the valve stem 2 and the valve head 3, wherein the surface 8 of the fillet 5 has an increased thermal resistance compared to the valve combustion face 4. The fillet surface 8 may have a thermal barrier coating 9, eg deposited by the spray nozzle (22, fig.3) of an atmospheric plasma spraying (APS) system or a high velocity oxygen fuel spraying (HVOF) system while the valve is rotating. The thermal barrier coating may comprise ferrite particles, a silica based inorganic compound, hollow ceramic balls or yttria-stabilised zirconia. The valve body may have a cavity 7 filled with sodium.

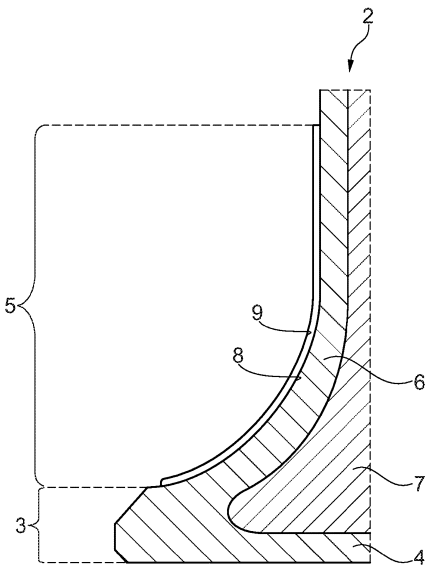

Fig. 2

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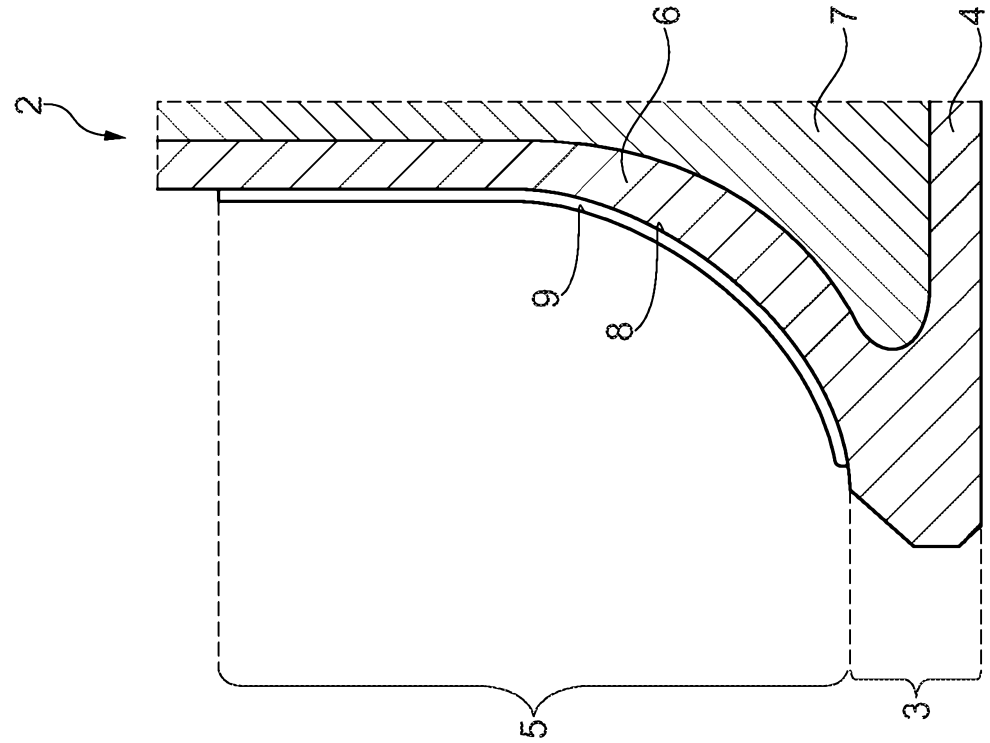

Fig. 2

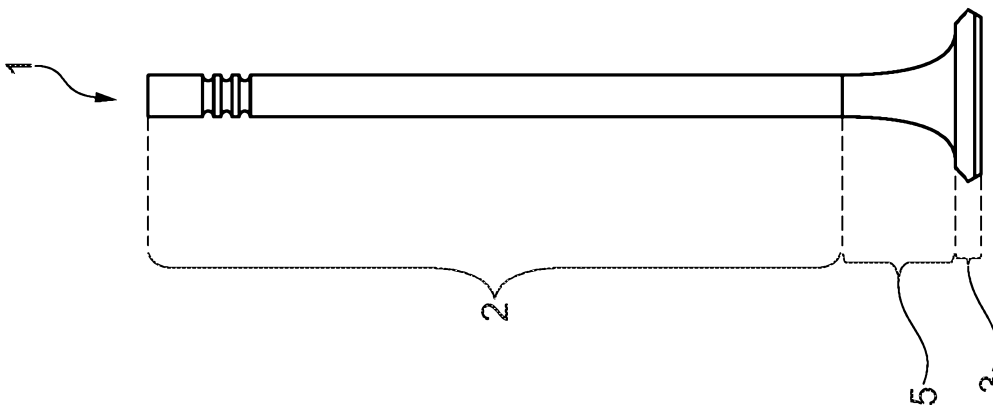

Fig. 1

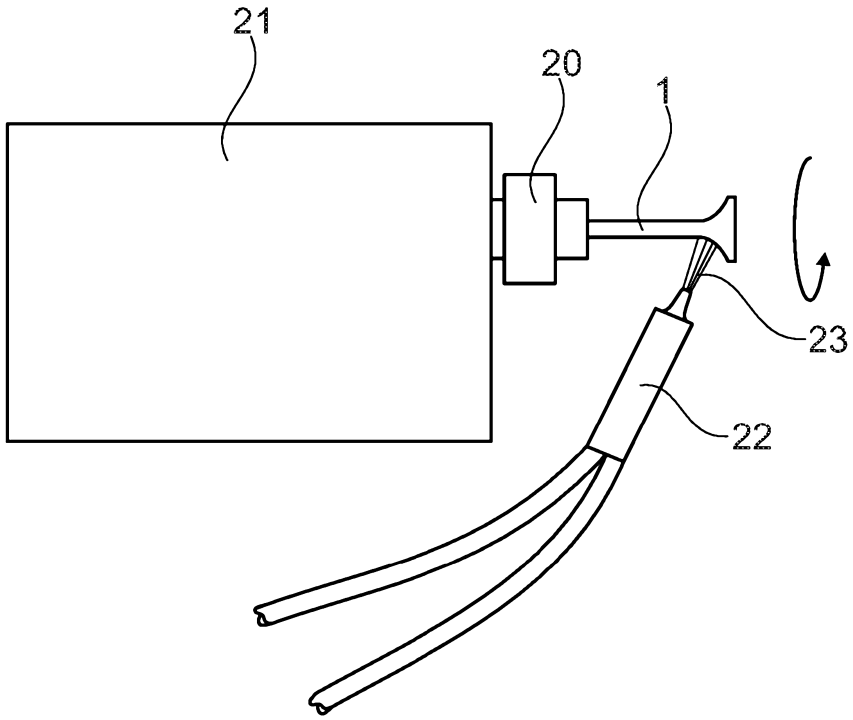

Fig. 3

Poppet valve

The invention relates to a poppet valve having a valve body comprising a valve stem body, a valve head body with a valve combustion face and a valve fillet body interconnecting the valve stem body and the valve head body.

Poppet valves are used in combustion engines. In such a combustion engine the valve combustion face is subjected to the hot combustion gases. Also the valve fillet body surface is subjected to the gases, when the combustion gases flow out of the cylinder along the valve fillet body surface. The hot combustion gases cause thermal stress in the poppet valve, which will lead to wear of the poppet valve.

US 5040501 discloses a poppet valve wherein by coating the entire head and stem of the poppet valve with synthetic diamond and overcoating or plating a solid lubricant, such as chromium on the outer surface of the diamond coating a number of advantages are achieved. These advantages included better heat and corrosion resistance, reduced wear resulting from seat and valve head impact contact and a reduction in the enlargement of surface cracks.

From US 6718932 it is known that the valve stem is coated with chromium plated coating, molybdenum sprayed coating, an Eatonite coating, physical vapor deposition (PVD) or chemical vapor deposition (CVD) type coatings or a nitride coating. Such coatings are typically used for reduction of friction.

Within different parts of a combustion engine it is furthermore known to apply coatings for insulation. For example US 4346556 discloses an insulating liner for use in an exhaust port of an internal combustion engine or the like, consisting of a formed thin wall tubular body of rigidized fibrous ceramic such as fibrous alumina-silica material with

an abrasion resistant ceramic coating fused onto the inner gas-exposed surface of the body. The coating comprises a mixture of fused silica cement and fine glass sintered in place on the body inner surface at a temperature below that which would damage the thin walls of the body.

It is furthermore known to provide hollow poppet valves filled with a heat conducting material, such as sodium. The cavity in the poppet valve can be arranged in the valve head body, the valve stem body or the full valve body. Furthermore, the hollow poppet valve can be manufactures out of one piece or more pieces, such as a head part and a stem part, which is then welded to the head part. The head could also be made by forging the head part and then closing the head part with a cap, which will form the valve combustion face.

The heat conducting material is transporting heat from the valve head to the valve stem and from there into the valve guide. However, combustion gases which leave the cylinder flow along the valve fillet body and will further heat up the poppet valve. This has a negative impact on the knocking properties of the combustion engine.

It is an object of the invention to reduce or remove the above mentioned disadvantages.

This object is achieved with a poppet valve according to the invention, which is characterized in that the valve fillet body surface has an increased thermal resistance compared to the valve combustion face.

With the poppet valve according to the invention heat is less susceptible to be taken up by the fillet body surface than by the valve combustion face by having the valve fillet body surface more resisting heat flow, i.e. having an increased thermal resistance.

It is the invention that the valve fillet body

surface resists taking up heat more than other surfaces. Preferably, the body parts themselves have a similar thermal resistance, such that once heat has been taken up, the heat can flow without further resistance through the poppet valve body, such that thermal stresses due to large temperature differences within the poppet valve body are reduced.

With the increased thermal resistance of the valve fillet body surface, the heat at the valve combustion surface can be transported away more easily resulting in a lower temperature of at least the valve combustion surface.

A high temperature on of the valve combustion face has a negative impact on the knocking tendency of an combustion engine. Now the temperature of the valve combustion face of a poppet valve according to the invention can be lowered the knocking tendency, with all the related disadvantages is reduced or even removed.

In a preferred embodiment of the poppet valve according to the invention a thermal barrier coating is arranged on the valve fillet body to provide an increased thermal resistance.

The thermal barrier coating ensures that the valve fillet body surface is less susceptible for taking up heat compared to a surface without an thermal barrier coating, such as the valve combustion face.

Preferably, the thermal barrier coating is provided by ferrite particles arranged by crystal growth, by a silica based inorganic compound, by spray painting of hollow ceramic balls or by a thermal spray of Yttria-stabilized zirconia.

These thermal barrier coatings provide a reliable and durable coating, which can endure the conditions present in a combustion engine.

In a further embodiment of the poppet valve according to the invention a bond coating is interposed

between the thermal barrier coating and the valve fillet body.

In order to further improve adherence of the thermal barrier coating to the valve fillet body, a suitable bond coating can be arranged between the valve fillet body and the thermal barrier coating.

Preferably, the coating thickness is between 0.1 mm and 0.6 mm, which allows for a sufficient increased thermal resistance, while the shape of the poppet valve is not influenced to a relevant degree.

In a further preferred embodiment of the poppet valve according to the invention the valve combustion face is uncoated.

By having an uncoated valve combustion face and a thermal barrier coating arranged on the valve fillet body the difference in thermal resistance is optimal. This ensures that heat from the valve combustion face can be transported optimally through the valve body towards the valve stem body and from there to the valve stem guide, without being hindered by additional heat flowing from the valve fillet body surface into the poppet valve body.

In yet a further preferred embodiment of the poppet valve according to the invention a cavity is arranged in the valve body and the cavity is filled with a heat conducting material, such as sodium. This cavity can be obtained by forging the poppet valve out of one piece, but it is also possible to obtain the valve out of two or more parts, which are welded together.

The cavity filled with the heat conducting material further promotes the heat flow from the valve combustion face towards the valve stem body and into the valve stem guide.

The invention further relates to a method for manufacturing a poppet valve according to the invention, which method comprises the steps of:

- providing a poppet valve having a valve body composed out of a valve stem body, a valve head body with a valve combustion face and a valve fillet body interconnecting the valve stem body and the valve head body;

- using either atmospheric plasma spraying (APS) or high velocity oxygen fuel spraying (HVOF) for arranging a thermal barrier coating on at least part of the valve fillet body surface.

With the method according to the invention, already available poppet valves can easily be adapted to a poppet valve according to the invention, simply by spraying the coating on the valve fillet body surface by using APS or HVOF.

In a preferred embodiment of the method according to the invention the poppet valve is rotated around the longitudinal axis, while the thermal barrier coating is arranged.

A regular poppet valve can for example be clamped in a rotating head, while a nozzle for using APS or HVOF is stationary arranged and directed to the valve fillet body. This allows for a quick application of a thermal barrier coating to the valve fillet body surface of a ready available poppet valve and also allows for automation of the process.

These and other features will be elucidated in conjunction with the accompanying drawings.

Figure 1 shows an embodiment of a poppet valve according to the invention.

Figure 2 shows an enlarged cross-sectional view of the poppet valve of figure 1.

Figure 3 shows an embodiment of the method according to the invention.

Figure 1 shows a poppet valve 1 with a valve stem body 2, a valve head body 3 with a valve combustion face 4 and a valve fillet body 5 interconnecting the valve stem body 2

and the valve head body 3.

The combined valve stem body 2, valve fillet body 5 and the valve head body 3 is designated as the valve body. Typically, the valve body is manufactured from one piece of material, or as two pieces of the same material welded together after forming.

Figure 2 shows an enlarged cross-sectional view of the poppet valve 1. The valve body 6 is provided with a cavity 7 filled with preferably sodium. The sodium provides a increased heat transfer within the valve body 6, such that heat of the combustion gases getting in contact with the valve combustion face 4 is transferred to the valve stem body 2, which will typically be guided within a valve stem guide of a combustion engine and allows for cooling of the poppet valve 1.

The valve fillet body surface 8 is coated with a thermal barrier coating 9, such that hot exhaust gases flowing along the valve fillet body 5 do not further increase the temperature of the poppet valve 1, or at least any heating up by the exhaust gases is reduced due to the thermal barrier coating 9.

Figure 3 shows schematically an embodiment of the method according to the invention. A poppet valve 1 is clamped into a clamping head 20 arranged to a housing 21 in which drive means are provided for rotating the clamping head 20 and accordingly for rotating the poppet valve 1.

Furthermore, a spray nozzle 22 is positioned in the direction of the fillet body part of the poppet valve 1. This spray nozzle 22 can be for example of an atmospheric plasma spraying (APS) system or high velocity oxygen fuel spraying (HVOF) system. The spray 23 is deposited on the poppet valve 1, while the poppet valve 1 is rotated, such that a thermal barrier coating is arranged on the valve fillet body surface

of the poppet valve 1.

List of reference signs

1. Poppet valve
2. Valve stem body
3. Valve head body
4. Valve combustion face
5. Valve fillet body
6. Valve body
7. Cavity
8. Valve fillet body surface
9. Thermal barrier coating
20. Clamping head
21. Housing
22. Spray nozzle
23. spray

Claims

1. Poppet valve (1) having a valve body (6) comprising a valve stem body (2), a valve head body (3) with a valve combustion face (4) and a valve fillet body (5) interconnecting the valve stem body (2) and the valve head body (3)

characterized in that

the valve fillet body surface (8) has an increased thermal resistance compared to the valve combustion face (4).

2. Poppet valve (1) according to claim 1, wherein a thermal barrier coating (9) is arranged on the valve fillet body (5) to provide an increased thermal resistance.

3. Poppet valve (1) according to claim 2, wherein the thermal barrier coating (9) is provided by ferrite particles arranged by crystal growth, by a silica based inorganic compound, by spray painting of hollow ceramic balls or by a thermal spray of Yttria-stabilized zirconia.

4. Poppet valve (1) according to claim 2 or 3, wherein a bond coating is interposed between the thermal barrier coating and the valve fillet body.

5. Poppet valve (1) according to claim 2, 3 or 4, wherein the coating thickness is between 0.1 mm and 0.6 mm.

6. Poppet valve (1) according to any of the preceding claims, wherein the valve combustion face (4) is uncoated.

7. Poppet valve (1) according to any of the preceding claims, wherein a cavity (7) is arranged in the valve body (6) and wherein the cavity (7) is filled with a heat conducting material, such as sodium.

8. Method for manufacturing a poppet valve (1) according to any of the preceding claims, which method comprises the steps of:

- providing a poppet valve (1) having a valve body (6) comprising a valve stem body (2), a valve head body (3) with a valve combustion face (4) and a valve fillet body (5) interconnecting the valve stem body (2) and the valve head body (3);

- using either atmospheric plasma spraying (APS) or high velocity oxygen fuel spraying (HVOF) for arranging a thermal barrier coating (9) on at least part of the valve fillet body surface (8).

9. Method according to claim 8, wherein the poppet valve (1) is rotated around the longitudinal axis, while the thermal barrier coating (9) is arranged.

Intellectual Property Office

Application No:	GB1721575.7	**Examiner:**	John Twin
Claims searched:	1 to 9	**Date of search:**	18 June 2018

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
X,Y	X:1,2,5,6; Y:3,4,8	US 2015/0308303 A1 (Lee et al./Hyundai Motor) - see eg. paras.42, 77; fig.1; an adiabatic coating 50 may be applied to "any one of" the stem, the face and the fillet
X,Y	X:1,2,5,6; Y:3,4,8	US 2015/0300215 A1 (Baek/Hyundai Motor) - see eg fig.1, para.43
X,Y	X:1,2,5,6; Y:3,4,8	CN 103925028 A (Mahle Tech.) - see eg figs. 1 & 2; note thermal barrier coating 3 on fillet region
X,Y	X:1,2,5,6; Y:3,4,8	JP 2008248735 A (Toyoda et al.) - see eg the EPODOC abstract and fig.3; note heat insulating layer 20
X,Y	X:1,2,6; Y:3,4,8	US 2008/0032065 A1 (Burton et al./High Performance Coatings) - see eg fig.4 showing fillet being coated with heat resistant material
X,Y	X:1,2,6; Y:3,4,8	JP 2003239076 A (Sumitomo Heavy Ind.) - see eg the EPODOC & WPI abstracts; figures; note heat resistant plating 5 on fillet
X,Y	X:1,2,6; Y:3,4,8	US 2007/0240668 A1 (Burton et al./High Performance Coatings) - see eg fig,2; note coating 118 eg of ceramic on fillet
Y	3,4	WO 93/13245 A1 (Detroit Diesel) - see eg p.10, last para.; note bond coat 14 and thermal coat 16 which may contain eg yttria-stabilised zirconia
Y	8	WO 2017/087734 A1 (Federal-Mogul) - see eg fig.3; para.42 - HVOF method
A	-	US 2010/0077983 A1 (Yamada/Aisan Ind.)

Categories:

Intellectual Property Office

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC[X] :

Worldwide search of patent documents classified in the following areas of the IPC

C23C; F01L

The following online and other databases have been used in the preparation of this search report

EPODOC, WPI

International Classification:

Subclass	Subgroup	Valid From
F01L	0003/04	01/01/2006