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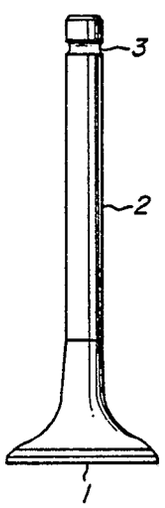
(54) Ceramic valves for use in internal combustion engines and a process for producing the same.

(57) The ceramic valve comprises a valve rod (2) and a valve body (1) provided at one end of the valve rod. The valve rod has an annular groove (3) at its other end, into which a cotter is to be fitted. The annular groove (3) possesses a surface roughness having a maximum height of not more than 3.2 μm. This prevents occurrence of cracks in the valve during extensive use. To produce such ceramic valves, the process comprises forming a shaped body in which a valve body and the annular groove are formed, and finish polishing the annular groove to a surface roughness having a maximum height of not more than 3.2 μm.

FIG_1



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CERAMIC VALVES FOR USE IN INTERNAL COMBUSTION ENGINES AND A PROCESS FOR PRODUCING THE SAME

The present invention relates to ceramic valves for use in internal combustion engines and a process for producing the same. More particularly, the invention is to provide ceramic valves free from occurrence of cracks at an annular groove into which a cotter is to be fitted.

Since ceramics have excellent strength at high temperatures and excellent wear resistance and are light in weight, they are considered promising as materials for valves in internal combustion engines.

For instance, Japanese patent application Laid-open No. 58-74,815 and Japanese utility model registration application Laid-open No. 60-92,711 disclose valves made of ceramics.

However, there is a problem in that when such a ceramic valve is used in an internal combustion engine, an annular groove into which a cotter is fitted is cracked during use.

It is an object of the present invention to provide ceramic valves free from occurrence of cracks during use.

It is another object of the present invention to provide a process for advantageously producing ceramic valves free from occurrence of cracks during use.

The present inventors analyzed ceramic valves having suffered cracks occurring at annular grooves during use, and they discovered that the cracks are originated from machining marks introduced during indispensable machining of the annular grooves.

The present invention is based on the above knowledge. That is, the present invention relates to a ceramic valves for internal combustion engines. The ceramic valves each comprises a valve rod, and a valve body provided at one end of the valve rod. The valve rod has an annular groove at the other end through which a cotter is fitted. The annular groove possesses a surface roughness having a maximum height of not more than 3.2 μm.

Further, the present invention relates to a process for producing ceramic valves for internal combustion engines, the valves each comprising a valve rod, and a valve body provided at one end of the valve rod, the valve rod having an annular groove through which a cotter is inserted at the other end, the process comprising the steps of forming a shaped body provided with the valve body and the annular groove, sintering the shaped body, and finish polishing the annular groove to a surface roughness having a maximum height of not more than 3.2 μm.

These and other optional features and advantages of the invention will be appreciated upon reading of the following description of the invention when taken in conjunction with the attached drawings, with the understanding that some modifications, variations and changes of the same could be made by the skilled person in the art to which the invention pertains.

Embodiments of the invention are described below with reference to the attached drawings, wherein:

Fig. 1 is a front view of a ceramic valve;

Figs. 2 and 3 are views illustrating annular grooves; and

Fig. 4 is a view illustrating a state in which such a ceramic valve is applied to an internal combustion engine.

Fig. 1 shows a ceramic valve produced according to the present invention.

In Fig. 1, reference numerals 1, 2 and 3 are a valve body, a valve rod, and an annular groove into which a cotter is fitted.

The annular groove is continuously formed along the outer peripheral surface of the valve rod 2 such that it has an arcuate section shown in Fig. 2 or that its section is defined by a straight segment and opposite arcuate end portions thereof. It is important to machine the annular groove 3 coaxially with the valve rod 2. It is preferable that an error in deviation of coaxiality is not more than 0.1 mm.

Next, a process for producing the above ceramic valve will concretely be described.

First, a batch powder of Si_3N_4 and a sintering aid such as MgO or Y_2O_3 are mixed and ground, and the obtained batch mixture is molded under press or extrusion. After a valve body and an annular groove are formed in the obtained molding by machining, it is fired. Alternatively, after the batch mixture is molded in a desired shape by injection, it is fired. Thereafter, the surface roughness of the annular groove is finished to not more than 3.2 μm Rmax by polishing with diamond or a grinding cutter.

In the production of the ceramic valve, it is important that the annular groove is coaxial with the valve rod. Thus, it is indispensable to machine the annular groove, which introduces machining traces inducing cracks at the surface of the annular groove.

Under the circumstances, the annular groove is polished such that the groove is finished to the surface roughness at which no machining traces remain. That is, the surface roughness is set at not more than 3.2

Rmax.

Examples

To 95% by weight of Si_3N_4 powder was added 5% by weight of a sintering aid such as MgO or Y_2O_3. After the mixture was mixed and ground for 3 hours by means of a vibration mill, and a formulated powder was obtained by granulating and drying it with a spray drier.

Next, a plurality of calcined products were prepared by molding the formulated powder under a pressure of 1.5 t/cm^2 by cold hydrostatic press with no annular groove being formed and calcining the moldings. After an annular groove is formed in each of the calcined products by machining, they are sintered in a nitrogen atmosphere at 1,600 ° C for one hour.

The annular groove of each of the sintered bodies was polished to a surface roughness given in Table 1 with a diamond grinding stone. For the comparison purpose, a part of the sintered products remained unpolished. Ten products were prepared for each group of test pieces.

With respect to each of the thus obtained ceramic valves, a cotter 5 was fitted into the annular groove as shown in Fig. 4, a spring 4 was fitted, and then it was tightened under a load of 40 kgf by a spring retainer 6 to obtain a valve for an internal combustion engine. Reference numerals 7 and 8 denote a valve guide and a valve seat, respectively. The valve was repeatedly subjected to the following test 5 times, and occurrence of cracks was checked. Results are also shown in Table 1.

Tester (Motoring tester)

Engine: gasoline engine (4 cylinders)
Valve-driving system: Direct driving system
Valve arrangement: DOHC
Spring load: 40 to 55 kgf
Lift amount: 10 mm

Testing conditions

Number of revolutions: 8,000 rpm
Oil temperature: 100 ° C
Water temperature: 80 ° C

Table 1

No.	Surface roughness (μm Rmax)	Use life cycle	Remarks
1	0.8	1×10^8	Invention Example
2	1.2	1×10^8	
3	2.5	1×10^8	
4	3.0	1×10^8	
5	3.2	1×10^8	
6	3.5	$1 \times 10^4 \sim 1 \times 10^5$	Comparative Example
7	4.5	$10 \sim 1 \times 10^3$	
8	8.1 (unpolished)	<10	

* Driving time was limited to 1×10^8 cycles at the maximum

From Table 1, it is seen that no cracks occurred during operation at $10x10^8$ cycles in the case of Run Nos. 1-5 meeting the present invention while cracks occurred in a short time for Comparative Examples (Run Nos. 6-8) falling outside the scope of the present invention in terms of the surface roughness.

According to the present invention, the ceramic valves which have excellent durability while suffering no occurrence of cracks during use can be produced. Thus, the invention enables the ceramic valves to be applied to the internal combustion engines.

Claims

1. A ceramic valve for use in an internal combustion engine, said ceramic valve comprising a valve rod, and a valve body provided at one end of the valve rod, the valve rod having an annular groove at the other end into which a cotter is to be fitted, and the annular groove having a surface roughness having a maximum height of not more than 3.2 μm.

2. A process for producing ceramic valves for use in internal combustion engines, said ceramic valves each comprising a valve rod, and a valve body provided at one end of the valve rod, the valve rod having an annular groove at the other end into which a cotter is to be fitted, said process comprising the steps of forming a shaped body in which a valve body and the annular groove are formed, and finish polishing the annular groove to a surface roughness having a maximum height of not more than 3.2 μm.

FIG_1

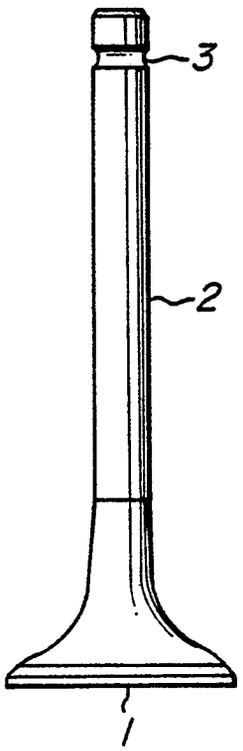


FIG_2

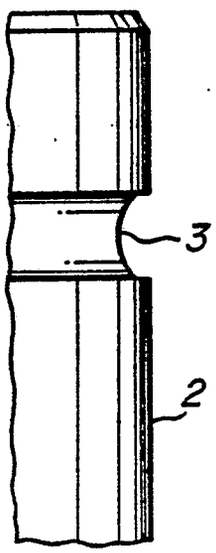


FIG_3

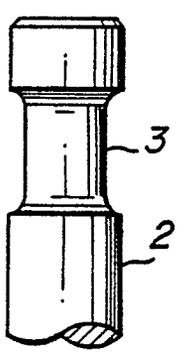
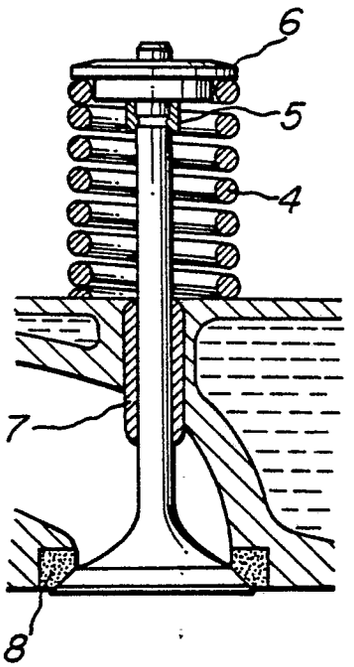


FIG_4



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EUROPEAN SEARCH REPORT

Application Number

EP 89 31 0486

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.5)
X	US-A-4359022 (NAKAMURA) * column 1, line 49 - column 2, line 24; figure 1 * ---	1, 2	F01L3/02 F01L3/10
A	EP-A-249503 (NGK) * page 3, line 26 - page 4, line 25; figure 1a * ---	1, 2	
A	"Adiabatic engines : Worldwide review SP-571" February 1984, Society of automotive engineers, Warrendale, pages 71-78 : "engine rig for screening ceramic materials" S.G. TIMONEY ---		
A	AUTOMOTIVE_ENGINEERING vol. 92, no. 2, February 1984, DALLAS pages 68 - 72; "NEW CERAMICS ADVANCE ADIABATIC DIESEL ENGINE" ---		
A	SCIENTIFIC AMERICAN. vol. 255, no. 4, October 1986, NEW YORK US pages 147 - 154; H. Kent Bowen: "Advanced_ceramics" -----		
			TECHNICAL FIELDS SEARCHED (Int. Cl.5) F01L F02F

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	09 FEBRUARY 1990	LEFEBVRE L.J.F.

CATEGORY OF CITED DOCUMENTS

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