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(54) Catalysed exhaust gas soot filter

(57) A catalysed soot filter (10) comprises a filter body having a plurality of inlet channels (22) and outlet channels (24) separated by porous walls (16) and arranged so that particle-laden gas to be filtered is forced to flow from said inlet channels (22) to said outlet channels (24) through said porous walls (16). A catalyst coating is provided in said inlet channels (22) on said porous walls (16). The catalyst coating is applied in such a way that said inlet channels (22) comprise at least two channel portions (U,D) with a different catalyst content.

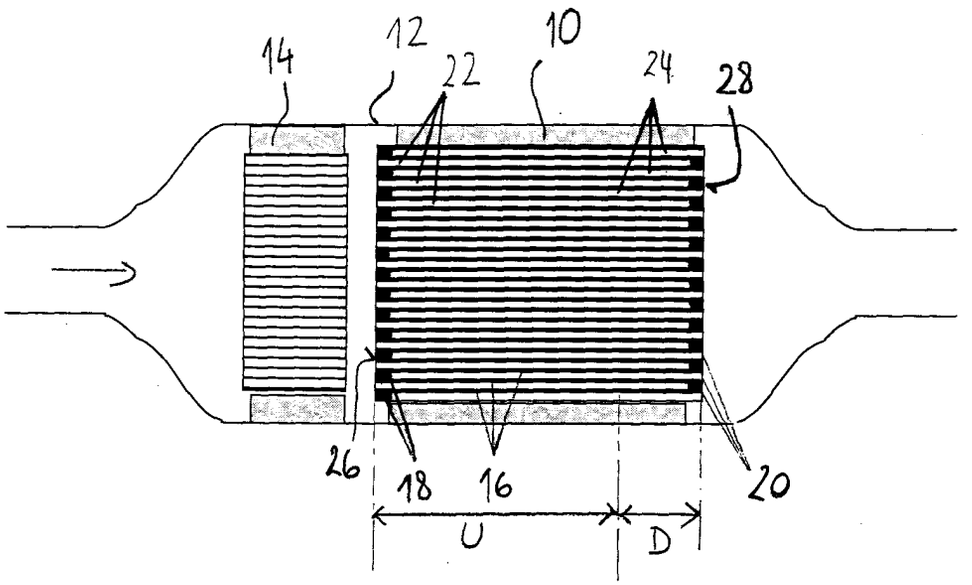

Fig.1

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Description

FIELD OF THE INVENTION

[0001] The present invention generally relates to engine exhaust gas treatment and more particularly to the filtering of soot particulates from diesel engine exhaust gas using a catalysed filter.

BACKGROUND OF THE INVENTION

[0002] Although soot filters (also commonly referred to as diesel particulate filter, particulate trap, soot catcher or bare trap) were already known on the experimental level since the 1980's, they only recently found real industrial application as severe environmental regulations have come into force, leading the automotive industry to heavily develop such systems. A soot filter typically comprises a plurality of inlet and outlet channels separated by porous walls. The exhaust gas is forced to flow from the inlet channels to the outlet channels through the porous walls, so that the unburned soot particulates are retained in the pores of the lateral walls, and accumulate and form a porous layer on the inner surfaces of the channel walls.

[0003] The biggest technical problem to be solved for continuous and reliable duty of a soot filter and of the upstream-located engine is to remove the soot particulates collected in the filter as they generate an excessive backpressure. Soot can be nearly totally eliminated when it is burned. This operation is commonly referred to as "filter regeneration" and has to be performed regularly. The soot particulates (mainly carbon) in contact with the oxygen in the exhaust gas are converted into CO and CO_2 during their combustion. This reaction only occurs at about 600°C, which are much higher than those at the soot filter inlet during normal operating conditions in most engines. Nevertheless, this combustion method has an industrial application in two major categories of soot filters.

[0004] A first category is based on a fuel borne additive, which acts as a catalyst to reduce the regeneration initiation temperature by approximately 50-100°C. Hence, the catalyst provides a combustion initiation at about 500-550°C. As soon as the engine management system detects an excessive backpressure in the soot filter, a regeneration operation is started. The exhaust gas temperature is artificially increased up to its possible maximum value (by e.g. late or post injection and/or reduction of intake air), which is high enough to obtain the ignition and the combustion initiation of the collected soot particulates contai n-ing the fuel additive. Unfortunately, this first category of soot filters involves increased complexity and maintenance, and thus high costs.

[0005] In the second category, there is no fuel additive, but the catalyst is provided directly in the filter. US 5,100,632, for example, describes such a catalysed soot filter, wherein a catalyst blend is present on the porous filter walls in the form of a coating or a film layer. The catalyst blend consists of a mixture of one or more platinum group metals and one or more alkaline earth metal oxides. The presence of this catalyst blend in the filter lowers the temperature at which ignition and incineration of the particulates collected on the filter walls may be effected so that continuous self-cleaning or regeneration of the filter can be accomplished at diesel exhaust temperatures encountered under certain engine operating conditions. Other types of catalysed soot filters do not necessarily use the catalyst blend of US 5,100,632, and may provide the supplementary energy needed for soot particulates ignition and combustion initiation with other catalytic blends or exhaust gas temperature increase cycles performed regularly (mainly with the engine management system).

[0006] Although engines equipped with such catalysed soot filters are advantageous in that they are less complex in use than fuel borne additive based systems, both technologies suffer from the fact that most catalysts are expensive precious metals.

OBJECT OF THE INVENTION

[0007] The object of the present invention is to provide a less expensive catalysed soot filter with excellent catalytic and filtering performances. This object is achieved by a catalysed soot filter as claimed in claim 1.

SUMMARY OF THE INVENTION

[0008] A catalysed soot filter in accordance with the invention comprises a filter body having a plurality of inlet channels and outlet channels separated by porous walls and arranged so that particle-laden gas to be filtered is forced to flow from the inlet channels to the outlet channels through these porous walls. A catalyst coating is applied in the inlet channels on the porous walls. Such a catalyst coating is typically used to reduce the activation energy of the soot combustion reaction; or in other words to lower the ignition and combustion temperature of particles accumulating thereon. According to an important aspect of the invention, the catalyst coating is applied in such a way that the inlet channels comprise at least two channel portions with a different catalyst content.

[0009] The catalysed soot filter of the invention thus does not have a fixed catalyst content throughout the inlet channels, but comprises two (or more) channel portions with differing catalyst contents. This allows to play on the catalyst content at different locations in the filter and namely to reduce the catalyst content where it is not (or less) necessary. This is more particularly the case in the rear or downstream portion (with regard to the flow direction of the gases) of the inlet channels. Indeed, these downstream portions of the inlet channels tend to get rapidly clogged by unburnable particles (e.g. mineral

ashes), which reduces the length of the inlet channels and causes gases to flow into the outlet channels via the porous walls further upstream of this clogged portion. Therefore, since this part of the filter will rapidly become ineffective, one may reduce the catalyst content in these downstream portions of the inlet channels. As a result, the upstream portions of the inlet channels shall advantageously have a greater catalyst content than the downstream portions.

[0010] In a preferred embodiment, the downstream channel portion of each inlet channel has a catalyst content tending towards zero. Alternatively, the downstream channel portion of each inlet channel has a catalyst content equal to zero. It will be appreciated that, by properly selecting the size of the downstream portion, it is possible to achieve an efficiency comparable to that of a soot filter with a uniform catalyst content along the whole inlet channels. An important merit of the present invention is thus to have observed that, surprisingly, with a lower total amount of catalyst in the filter, but that is properly applied in the filter, it is possible to achieve excellent results with reduced costs.

[0011] Preferably, the upstream portion represents between 60 and 90 % of the length of the inlet channel, more preferably between 70 and 80 %. With such catalyst coating portions, the obtained filter performs as good as a conventional filter where the catalyst coating is uniformly applied over the whole length of the inlet channels. Although such a two-portion configuration is preferred, it would be possible to have a succession of portions containing decreasing amounts of catalyst towards the bottom of the inlet channels.

[0012] Hence in the present invention, the catalyst coating is applied in each portion of the inlet channels in a controlled manner in accordance with the catalyst content to be provided in these portions. This means that the differences in catalyst content along the channels are not accidental (e.g. due to poor process controllability).

[0013] It is to be noted that another way of playing on the catalyst content in the filter is, instead of varying the amount of catalyst, to vary the nature of the catalyst in each portions of an inlet channel, or vary both the amount and nature.

[0014] The filter body preferably has an inlet side and an outlet side, and the inlet and outlet channels extend from the inlet side to the outlet side. The inlet channels are open on the inlet side for the particle laden exhaust-gas to enter the filter and the outlet channels are closed on the inlet side. The outlet channels are open on the outlet side for the filtered exhaust-gas to exit the filter and the inlet channels are closed on the exhaust side. In addition, each inlet channel is adjacent to a predetermined number of channels and each outlet channel is adjacent to the same predetermined number of inlet channels, except at the periphery of the soot filter. This predetermined number of channels is comprised between 3 and 6. Preferably, it is equal to 4 or to 6, in which case it forms a honeycomb structure.

[0015] Regarding more specifically the catalyst coating, it preferably comprises catalytic substances which permit to reduce the activation energy of the soot combustion reaction. A preferred catalytic coating comprises a mixture of at least one platinum group metal and at least one alkaline earth metal oxide. The catalyst coating is preferably uniformly applied in the upstream channel portion that a predetermined amount of catalyst is deposited.

[0016] It remains to be noted that, although the present catalysed soot filtered is particularly suited to be used in diesel engines, it may be used in a variety of applications relating to the filtering of soot particles carried in a gas. In particular, it may also find application in the filtering of gasoline engine exhaust gas for future emission requirements.

[0017] According to another aspect of the present invention, a method for manufacturing a catalysed soot filter comprises the steps of:

providing a filter body having a plurality of inlet channels and outlet channels separated by porous walls and arranged so that particle-laden gas to be filtered is forced to flow from said inlet channels to said outlet channels through said porous walls; and

applying a catalyst coating on the porous walls of the inlet channels.

[0018] According to an important aspect of the present method, the catalyst coating is applied in such a way that the inlet channels comprise at least two channel portions with a different catalyst content.

[0019] The catalyst coating is preferably applied in such a way as to form an upstream channel portion having a greater catalyst content than a downstream channel portion.

[0020] In a preferred embodiment, the downstream channel portion has a catalyst content equal to, or tending towards, zero. The upstream portion may have a length representing between 60 and 90 % of the length of said inlet channel, preferably between 70 and 80 %.

[0021] The catalyst coating in the upstream channel portion can be applied by immersion in a solution containing the desired catalyst composition.

BRIEF DESCRIPTION OF THE DRAWINGS

[0022] The present invention will now be described, by way of example, with reference to the accompanying drawings, in which:

FIG.1: is a longitudinal schematic section view through a filter assembly including a preferred embodiment of a soot filter in accordance with the invention; and

FIG.2: is a perspective cutaway view schematically illustrating the cell structure of a soot filter.

DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT

[0023] Fig.1 shows a preferred embodiment of a soot filter 10 in accordance with the invention, which is disposed in a filter housing 12 including a diesel oxidation catalyst 14. The oxidation catalyst 14 is provided to oxidize CO and hydrocarbons in the exhaust gas under normal operation, and permits to increase the temperature of the exhaust gases in the filter regeneration mode with post injection. The filter 10 preferably includes a ceramic monolith body (made e.g. of SiC or cordierite) having a plurality of porous internal walls 16. The walls 16 define square cross-sectioned parallel passages, the alternate ends of which are plugged by end walls 18, 20 to define a plurality of adjacent inlet and outlet channels, 22 and 24 respectively. In the present embodiment, the inlet and outlet channels 22, resp. 24, extend between inlet and outlet sides of the filter 26, resp. 28. As can be better seen from Fig.2, the inlet and outlet channels 22, 24, configuration is such that each inlet channel 22 is in communication with four outlet channels 24 via the porous walls 16, except at the periphery of the filter. The flow of exhaust gas arriving on the inlet side 26 will enter the inlet channels 22, flow into the outlet channels 24 through the porous channel walls 16-whereby the soot particles deposit on the inlet channel walls-and exit the outlet channels 24 on the outlet side 28. The porosity of the porous walls 16 is selected so that most or all of the particles are restrained from passing through the filter with the gas, so that the filtered particulates collect on surfaces of the porous inlet channel walls. With time, soot particles (mainly carbonaceous material) accumulate on the inlet channel walls, which must undergo regeneration to burn these soot particles.

[0024] The present filter 10 is provided with a catalyst coating or film (not shown in the drawings) in the inlet channels 22 in order to reduce the activation energy of the soot combustion reaction, so that the cleaning or regeneration of the particles collected on the filter walls can be effected at diesel exhaust gas temperatures encountered under certain engine operating conditions (in particular lower temperatures than those required for the fuel borne catalyst systems).

[0025] It will be appreciated that the inlet channels 22 of the soot filter 10 are provided with a catalyst coating that has been applied in a controlled manner in such a way that there are two channel portions with a different catalyst content. More precisely, in the present embodiment, an upstream portion of the channel is coated with a catalyst coating having a predetermined catalyst content C1, whereas a downstream part of the inlet channels has a catalyst content equal to zero or tending towards zero. In other words, there is no (or almost no) catalyst coating on the downstream portion of the channels. Preferably, the upstream portion corresponds to about 70 to 80% of the length of the inlet channels. This is indicated in Fig.1 by the arrow "U", which thus represents the front inlet channel portion having a catalyst coating, and the rear, downstream part without catalyst or with an insignificant amount of catalyst is indicated "D".

[0026] It has been surprisingly discovered that the lack of catalyst coating on the downstream portion of the inlet channel does not affect the performance of the filter. This is believed to be due to the fact that with such a proportion of coating in the inlet channel, the combustion heat generated in the upstream parts of the channels is sufficient to sustain the auto-combustion of soot in the downstream part of the channels. In addition, downstream portions of the inlet channels will anyhow be covered with cakes of ashes from the mineral components in the engine oil. So, with time, this portion of the inlet channels would become inactive, even if provided with a catalyst coating.

[0027] In practice, the catalyst coating is applied by immersion in a solution containing the desired catalyst composition to a depth equal to the desired proportion of inlet channel length (about 75 % of the length of the inlet channels in Fig.1). Such a solution containing the catalyst may include e.g. a mixture of at least one platinum group metal and at least one alkaline earth metal oxide at a given concentration. The catalyst will thus deposit on the channel walls over a length corresponding to the upstream portion, and thereby form a catalyst coating (or film) with a certain amount of catalyst per surface unit.

[0028] It will be understood that the catalyst coating is applied in a controlled manner to provide in each portion a catalyst content equal to a design value. However, within a given channel portion, there may be small variations about this design value at two different locations of this channel portion. When comparing the catalyst contents between e.g. an upstream and a downstream channel portion, one may thus use mean values of catalyst content.

Claims

1. A catalysed soot filter comprising a filter body having a plurality of inlet channels (22) and outlet channels (24) separated by porous walls (16) and arranged so that particle-laden gas to be filtered is forced to flow from said inlet channels (22) to said outlet channels (24) through said porous walls (16), a catalyst coating being applied in said inlet channels (22) on said porous walls (16), **characterised in that** said catalyst coating is applied in such a way that said inlet channels comprise at least two channel portions with a different catalyst content.

2. The catalysed soot filter according to claim 1, **char-**

acterised in that said inlet channels (22) comprise an upstream channel portion (U) and a downstream channel portion (D), said upstream channel portion (U) having a greater catalyst content than said downstream channel portion (D).

3. The catalysed soot filter according to claim 2, **characterised in that** said downstream channel portion (D) has a catalyst content tending towards zero.

4. The catalysed soot filter according to claim 2, **characterised in that** said downstream channel portion (D) has a catalyst content equal to zero.

5. The catalysed soot filter according to claim 2, 3 or 4, **characterised in that** said upstream channel portion (U) has a length representing between 60 and 90 % of the length of said inlet channel, preferably between 70 and 80%.

6. The catalysed soot filter according to any one of the preceding claims, **characterised in that**
said filter body has an inlet side (26) and an outlet side (28), and said inlet and outlet channels (22, resp. 24) extend from said inlet side (26) to said outlet side(28);
said inlet channels (22) are open on the inlet side (26) for the particle laden exhaust-gas to enter the filter and said outlet channels (24) are closed on said inlet side (26); and
said outlet channels (24) are open on said outlet side (28) for the filtered exhaust-gas to exit said filter and said inlet channels (22) are closed on said exhaust side (28).

7. The catalysed soot filter according to any one of the preceding claims, **characterised in that** except at the periphery of said filter body, each inlet channel (22) is adjacent to a predetermined number of outlet channels (24); and each outlet channel (24) is adjacent to the same predetermined number of inlet channels (22).

8. The catalysed soot filter according to the preceding claim, **characterised in that** said predetermined number of channels is comprised between 3 and 6.

9. The catalysed exhaust gas soot filter according to any one of the preceding claims, **characterised in that** said filter body is made of ceramic material, preferably constructed as a monolithic structure.

10. The catalysed soot filter according to any one of the preceding claims, **characterised in that** said catalyst coating comprises at least one platinum group metal and at least one alkaline earth metal oxide.

11. The catalysed soot filter according to any one of the preceding claims, **characterised in that** said catalyst coating is uniformly applied in said upstream portion (U) with a predetermined amount of catalyst.

12. A method for manufacturing a catalysed soot filter comprising the steps of:

providing a filter body having a plurality of inlet channels and outlet channels separated by porous walls and arranged so that particle-laden gas to be filtered is forced to flow from said inlet channels to said outlet channels through said porous walls; and

applying a catalyst coating in said inlet channels on said porous walls;

characterized in that said catalyst coating is applied in such a way that said inlet channels comprise at least two channel portions with a different catalyst content.

13. The method according to claim 12, **characterised in that** said catalyst coating is applied in such a way as to form an upstream channel portion having a greater catalyst content than a downstream channel portion.

14. The method according to claim 13, **characterised in that** said downstream channel portion has a catalyst content equal to, or tending towards, zero.

15. The method according to claim 13 or 14, **characterised in that** said upstream portion has a length representing between 60 and 90 % of the length of said inlet channel, preferably between 70 and 80 %.

16. The method according to claim 13, 14 or 15, **characterised in that** said catalyst coating in said upstream channel portion is applied by immersion in a solution containing the desired catalyst composition.

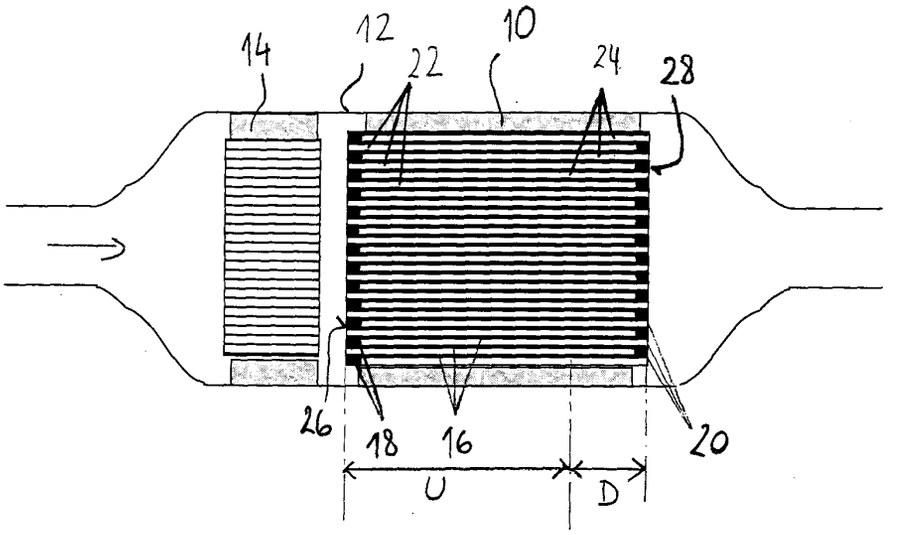

Fig.1

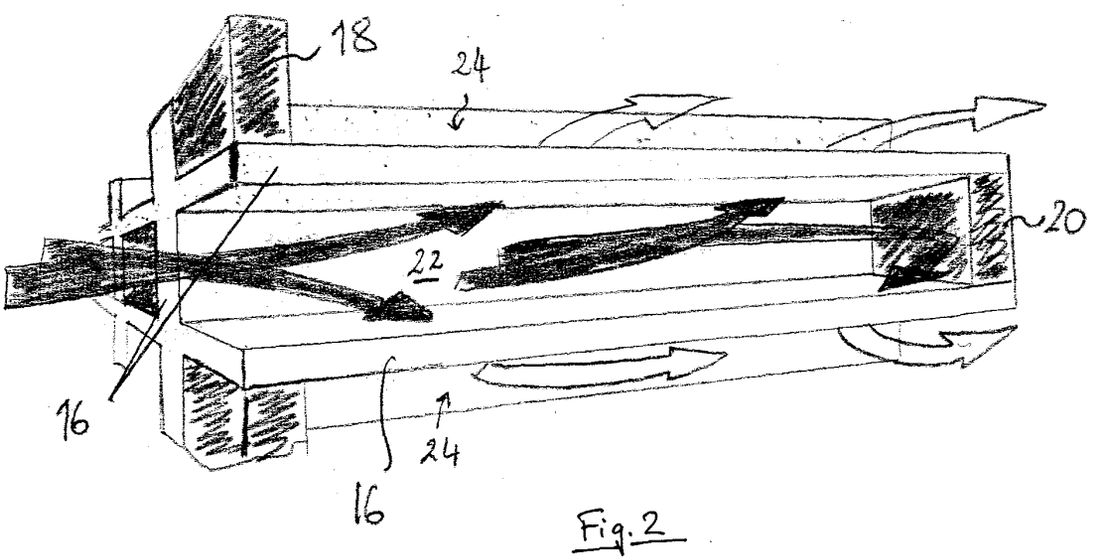

Fig.2

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 03 10 4385

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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	29 March 2004	Ikas, G

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
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E : earlier patent document, but published on, or after the filing date
D : document cited in the application
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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 03 10 4385

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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