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(54) Particulate filter

(57) Particulate filter (1) for cleaning exhaust gases of an internal combustion engine, with a substrate (3) traversed by flow channels (2) and at least partially comprising a catalytic coating and comprising an inflow region (4) and an outflow region (5), wherein the particulate filter (1) comprises a first flow section (6) which faces towards the inflow region (4) and which is connected to an electric heating means (7), and a second flow section (8) which faces away from the inflow region (4) and which is designed without heating means.

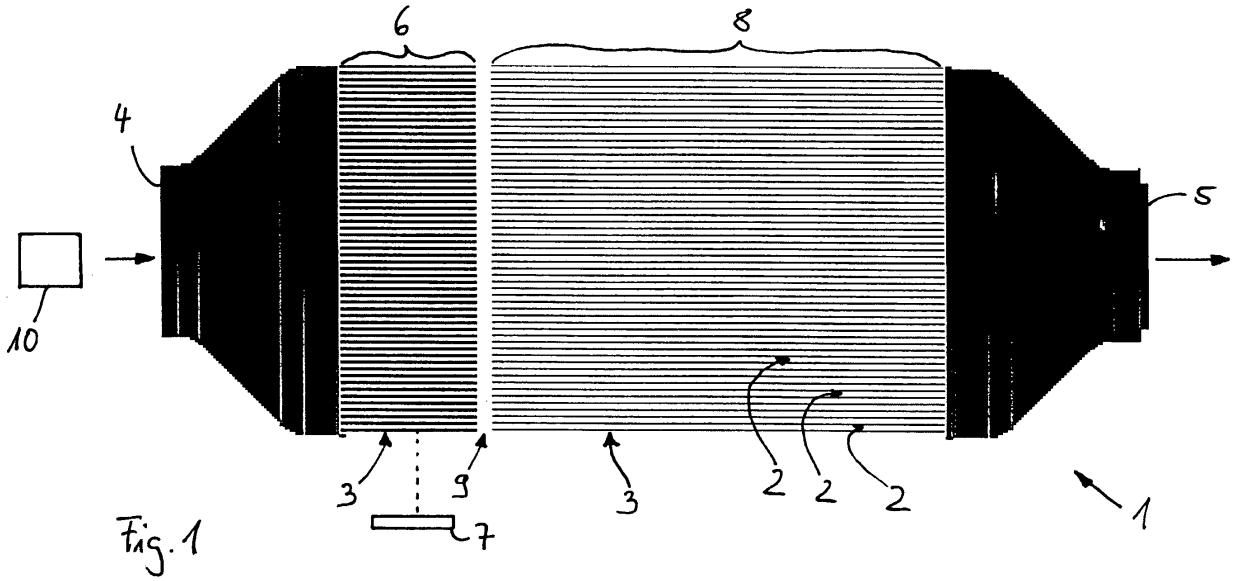

Fig. 1

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Description

[0001] The invention concerns a particulate filter for cleaning exhaust gases of an internal combustion engine, consisting of a substrate traversed by flow channels and comprising an inflow region and an outflow region.

[0002] For the reduction of pollutant emissions and in particular particulate emissions from diesel engines, the use of particulate filters is known. Since during continuous operation of a diesel engine a more or less large number of particulates is deposited in the filter, regeneration of the particulate filters is necessary in order to ensure serviceability of such a particulate filter and of the correspondingly equipped diesel engine over a longer period of time. But the actual difficulty lies not in filtration of the diesel particulates, but in regeneration of the filters used. Carbon black burns spontaneously only at temperatures of about 650°C. But these temperatures are reached e.g. by modern diesel engines in general only at full load and even there too rarely. Therefore additional, supporting measures for oxidation of the particulates separated from the exhaust gas are necessary. Particularly when cold starting, measures of this kind are necessary as the whole exhaust system and the exhaust gas do not yet exhibit a temperature necessary for regeneration.

[0003] A distinction is made between active and passive regeneration measures. With the active measures, the temperature of the exhaust gas is raised, for example, by using an electric heating means, above the temperature threshold necessary for oxidation of the particulates. US 5,259,190 describes a particulate filter which can be regenerated by electric heating. With this filter, in case of regeneration, uniform heating of the whole cross-sectional area of the particulate filter is obtained so that all filter cells are regenerated simultaneously. Measures of this kind are always associated with an increased load on the electrical system of the vehicle and hence extra fuel consumption.

[0004] With the passively attacking systems, the particulate ignition temperature is lowered e.g. by using organometallic fuel additives. A disadvantage of this passive regeneration method is that after regeneration of the particulate filter the additive accumulates in the filter in the form of an ash, e.g. cerium ash. Added to this is an ash from combustion of the lubricating oil discharged with the exhaust gas (oil ash). The cerium ash, which can be approximately two-thirds of the total ash, together with the oil ash forms a powdered, flocculent composition which remains in the filter as a residue after combustion of the carbon black. After a certain period of operation of the internal combustion engine, depending on the size and oil consumption of the engine several hundred grammes of the ash can accumulate in the filter and considerably increase the exhaust backpressure which is associated with continuously increasing extra fuel consumption. Therefore systems of this kind are not designed for the whole life of a vehicle either.

[0005] It is the object of the invention to provide a particulate filter which avoids the above drawbacks in regeneration, and in particular constitutes a simple and compact unit, at the same time avoiding high manufacturing and production costs. Furthermore, a particulate filter which particularly when cold starting the motor vehicle allows satisfactory regeneration of the particulate filter was to be provided.

[0006] The object is achieved by a particulate filter with the characteristics of claim 1. In the dependent claims the advantageous developments of the particulate filter according to the invention are described.

[0007] According to the invention the particulate filter comprises a first flow section which faces towards the inflow region and which is connected to an electric heating means. Furthermore the particulate filter comprises a second flow section which faces away from the inflow region and which is designed without heating means. The particulate filter according to the invention makes it possible, particularly when cold starting the motor vehicle when the exhaust gases of the internal combustion engine have a low temperature (depending on the outside temperature, 100°C-150°C), to obtain satisfactory regeneration of the particulate filter. While the exhaust gas passes through the inflow region into the first flow section of the particulate filter, a catalytic reaction is brought about in the first flow section by the catalytic coating of the substrate. Preferably the catalytic coating comprises noble metals, for example, platinum and/or palladium and/or rhodium. Platinum and palladium in this case can considerably accelerate the oxidation of hydrocarbons and carbon monoxide, while rhodium favours the reduction of nitrogen oxides. The catalytic coating forms a heavily charged (sharp) oxidation catalyst which adsorptively splits (dissociates) the oxygen atoms contained in the exhaust gas at noble metal centres. By rapid activation of the electric heating means at the right time, the first flow section is brought to the temperature at which there is spontaneous ignition of the (filtered) particulates contained in the first flow section. It turned out that at a temperature of the first flow section of about 500°C-650°C, spontaneous ignition of the particulates is always enabled. In this operation the soluble organic fractions (SOF) which are always deposited on the particulates acquire an important role. Due to the heating process, relatively high-boiling components (sometimes also fuel residues) are detached from the particulates (desorption). As a result, highly inflammable vapours form in the immediate vicinity of the coating and the oxygen atoms adsorbed thereon. These vapours ignite directly on the already (thermally) activated catalyst coating, which results locally in subsequent burn-off of particulates in the first flow section.

[0008] While the particulates are burnt off in the first flow section, heat of reaction (exothermy) is released, which is absorbed by the exhaust gas flowing through the particulate filter. The exhaust gas flowing into the second inflow region is heated up sufficiently by the heat

obtained for particulates to be burnt off in the second inflow region of the particulate filter as well, but without raising or keeping this second inflow region at a given temperature by the electric heating means. According to the present invention, merely initial ignition in the first flow section of the particulate filter is sufficient to cause further combustion of the carbon black accumulated in the whole particulate filter, with oxygen. Since only the first inflow region of the particulate filter must be raised to a given temperature by heating, a substantial amount of electrical energy can be saved.

[0009] In a preferred embodiment of the invention the substrate of the first flow section comprises a particularly heat-conductive material which can preferably be a light metal, for example, magnesium, calcium, etc. In one embodiment of the invention the heat-conductive material can be applied by vapour deposition, e.g. by gas phase separation (CVD/PVD method). In a further alternative embodiment the heat-conductive material can be applied by an impregnating process to the substrate of the first flow section. By repeated immersion in a metal salt-containing solution and by repeated drying, reliable impregnation of the heat-conductive material can be obtained. Similarly all electrochemical coating methods can be employed. Other alternative methods are conceivable, of course. Due to the good thermal conductivity of the first inflow region, rapid heating of this particulate filter component by the electric heating means to a desired temperature at which there is spontaneous ignition of the particulates can take place.

[0010] In an alternative of the invention the first and the second flow sections can be two separate components. Preferably the first and the second inflow regions are arranged in a common housing. Attachment of the two inflow regions to the housing can be done by form-locking and/or force-locking and/or material-locking connection, for example. Appropriately the first and the second flow sections are spaced apart by a distance which serves in particular as an insulation gap. This insulation gap runs essentially perpendicularly to the exhaust flow. One of the advantages of an insulation gap of this kind is that satisfactory heating of the first flow section can take place within a short time without a substantial amount of heat from the substrate of the first inflow region being lost directly to the substrate of the second inflow region.

[0011] In a further alternative the first and the second flow sections can be joined to each other in one piece.

[0012] The substrate can in a preferred embodiment be made of ceramic. It is, however, also possible to make the substrate of metal. The essential advantage of a ceramic substrate is that the noble metal coating can be recovered substantially more easily than with a metal substrate. Furthermore a ceramic substrate is cheaper to make and easier to coat. The metal substrate, which can consist of a rolled-up, corrugated metal sheet, for example, is advantageously very thin and so has a lower weight compared with the ceramic substrate, and any number of shapes. Furthermore the metal substrate contributes to better thermal conductivity and consequently a homogeneous temperature distribution in the first and second flow regions.

[0013] In a further embodiment of the invention the first flow section has a volume which is not more than 40% in relation to the volume of the sum of the first and second flow sections. It may be quite sufficient for the first flow section to occupy only 10-20% of the total volume in order to obtain satisfactory regeneration of the particulate filter. However, this depends on different boundary conditions, for example, the internal combustion engine used, the geometry of the particulate filter or the noble metals used in the first flow section.

[0014] Appropriately an evaporator unit - in particular for diesel fuel - can be mounted in front of the particulate filter. The evaporator unit mounted in front can, for example, furnish unburnt hydrocarbons (HC) in gaseous form which are transported by the exhaust stream into the particulate filter. Due to these hydrocarbons furnished, which are extremely inflammable in the evaporated state, particulate ignition in the first flow section is assisted. Activation of the evaporator unit is, for example, possible when the carbon black contained in the first flow section of the particulate filter is too dry (graphitised) and so can be ignited only with great difficulty. Activation of the evaporator unit can take place as a function of operating point and as needed.

[0015] Further advantages, characteristics and details of the invention are apparent from the description below in which, with reference to the drawing, a practical example of the invention is described in detail. Here, the characteristics mentioned in the claims and in the description can in each case be essential to the invention individually on their own or in any combination. It shows:

Figure 1 a particulate filter according to the invention with a first or a second flow section.

[0016] Figure 1 shows a particulate filter 1 according to the invention in a purely schematic view. The particulate filter has a substrate 3 which is traversed by flow channels 2 and which comprises an inflow region 4 and an outflow region 5. Further, the particulate filter 1 includes a first flow section 6 which faces towards the inflow region 4 and which is connected to an electric heating means 7. The particulate filter further comprises a second flow section 8 which faces away from the inflow region 4 and which is designed with no heating means. In this embodiment of the invention the first flow section 6 is provided only with a catalytic coating. The catalytic coating here is noble metals, for example, platinum and/or palladium and/or rhodium.

[0017] The flow channels 2 of the particulate filter 1 are of square construction in the embodiment shown. Naturally the cross-section of the flow channel 2 can be pentagonal, hexagonal or polygonal. Alternatively a circular cross-section of the flow channels 2 is possible too.

[0018] As Figure 1 shows, the first 6 and the second 8 inflow regions are each constructed as a component. The first flow section 6 is spaced apart from the second flow section 8 by a gap 9. This gap 9 (distance between the first flow section 6 and the second flow section 8) is as a rule smaller than 1 mm.

[0019] The substrate 3 of the first flow section 6 is provided with a heat-conductive layer. Here, the heat-conductive layer is a light metal made of magnesium. The use of alternative light metals which can be applied to the substrate 3 by vapour deposition, for example, is of course conceivable. In front of the particulate filter 1 is mounted an evaporator unit 10, shown purely schematically, which as necessary adds to the exhaust gas a certain quantity of unburnt hydrocarbons (HC) in gaseous form. As Figure 1 shows, the first flow section 6 has a volume which is smaller than 30% in relation to the volume of the sum of the first 6 and the second 8 flow sections.

[0020] The present particulate filter 1 is distinguished by good regeneration properties, particularly when cold starting the internal combustion engine, not shown. In this case the still relatively cold exhaust gas flows at a temperature of about 100°C through the inflow region 4 of the particulate filter 1 and passes into the first flow section 6. On account of the catalytic coating of the first flow section 6, oxygen splitting occurs, which favours ignition of the carbon black particulates located in the first flow section 6 under activation by the electric heating 10. The electric heating 10 here heats the first flow section 6 to a temperature of about 600°C.

[0021] The heat-conductive material of the substrate 3 of the first flow section 6 favours homogeneous heat distribution. In order to keep loss of heat as low as possible, the gap 9 serves as an insulator. This prevents heat from passing via the substrate of the first flow section 6 through the gap 9 into the substrate 3 of the second flow section 8. Due to the heated first flow section 6, spontaneous ignition of the particulates occurs, heat being released as a result of the burn-off of particulates and transported by the exhaust stream in the direction of the outflow region 5. The heated exhaust gas then passes through the gap 9 into the second flow section 8 and there likewise triggers burn-off of particulates. It is particularly advantageous that only a certain energy of activation must be delivered from outside by the heating means 10 to the particulate filter 1 or to the first flow section 6, in order for an independent particulate burn-off process to take place in the whole particulate filter 1. The heating 10 can be induction heating, heating-wire heating or semiconductor heating, for example.

[0022] In the event that the particulates within the particulate filter 1 are too dry, it is possible to introduce unburnt hydrocarbons (HC) in gaseous form into the exhaust stream via the evaporator 10, facilitating ignition of the particulates in the first flow section 6.

List of reference numbers

[0023]

1	particulate filter
2	flow channels
3	substrate
4	inflow region
5	outflow region
6	first flow section
7	electric heating means
8	second flow section
9	distance, gap, insulation gap
10	evaporator unit

Claims

1. Particulate filter (1) for cleaning exhaust gases of an internal combustion engine, with a substrate (3) traversed by flow channels (2) and at least partially comprising a catalytic coating and comprising_an inflow region (4) and an outflow region (5), **characterised in that** the particulate filter (1) comprises a first flow section (6) which faces towards the inflow region (4) and which is connected to an electric heating means (7), and a second flow section (8) which faces away from the inflow region (4) and which is designed without heating means.

2. Particulate filter (1) according to claim 1, **characterised in that** the substrate (3) of the first flow section (6) comprises a heat-conductive material.

3. Particulate filter (1) according to claim 2, **characterised in that** the heat-conductive material is a light metal.

4. Particulate filter (1) according to any of the preceding claims, **characterised in that** the first (6) and the second (8) flow sections are joined to each other in one piece.

5. Particulate filter (1) according to any of claims 1 to 3, **characterised in that** the first (6) and the second (8) flow sections are spaced apart by a distance (9).

6. Particulate filter (1) according to any of the preceding claims, **characterised in that** the flow channels (2) have a square, pentagonal, hexagonal, polygonal or circular cross-section.

7. Particulate filter (1) according to any of the preceding claims, **characterised in that** the substrate (3) is made of a ceramic or metal.

8. Particulate filter (1) according to any of the preceding claims, **characterised in that** the first flow section

(6) has a volume which is not more than 40% in relation to the volume of the sum of the first (6) and the second (8) flow sections.

9. Particulate filter (1) according to any of the preceding claims, **characterised in that** an evaporator unit (10) is mounted in front of the particulate filter (1) .

10. Particulate filter (1) according to any of the preceding claims, **characterised in that** the catalytic coating comprises noble metals.

11. Motor vehicle with a particulate filter (1) according to any of the preceding claims.

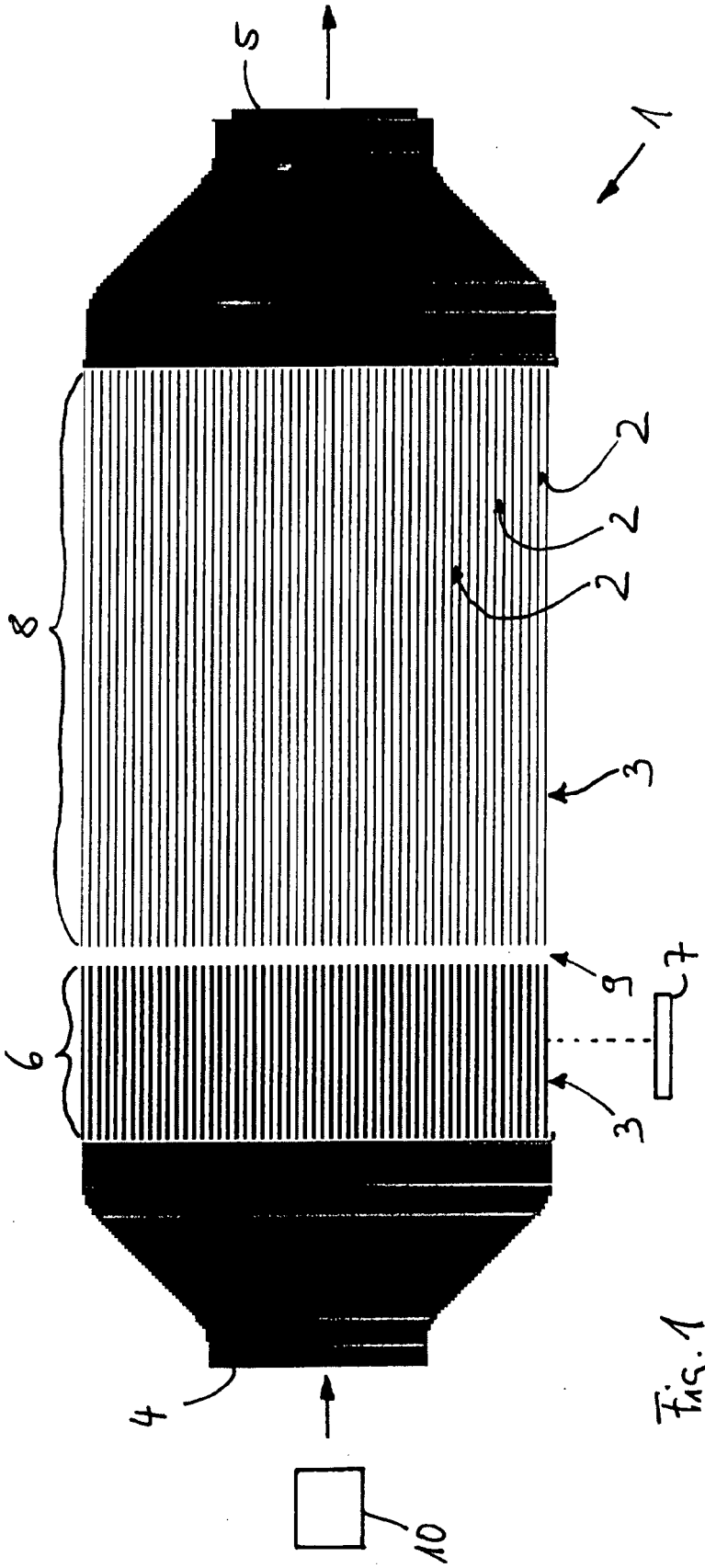

Fig. 1

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EUROPEAN SEARCH REPORT

Application Number
EP 07 02 4177

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 2006/021335 A1 (OPRIS CORNELIUS N [US]) 2 February 2006 (2006-02-02) * paragraph [0018] - paragraph [0020]; figure 1 * * paragraph [0022] * * paragraph [0025] * -----	1,2,5,7, 10,11	INV. F01N3/022 F01N3/035
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TECHNICAL FIELDS SEARCHED (IPC)

F01N

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	12 March 2008	Tatus, Walter

CATEGORY OF CITED DOCUMENTS

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

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