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Yagi et al.

(54) **EXHAUST GAS PURIFYING CATALYST DEVICE**

(71) Applicant: **Kabushiki Kaisha F.C.C.**, Hamamatsu-shi (JP)

(72) Inventors: **Shintaro Yagi**, Hamamatsu-shi (JP); **Ryou Suzuki**, Hamamatsu-shi (JP); **Yusuke Ogata**, Hamamatsu-shi (JP); **Sho Taniguchi**, Hamamatsu-shi (JP)

(73) Assignee: **Kabushiki Kaisha F.C.C.**, Hamamatsu-shi (JP)

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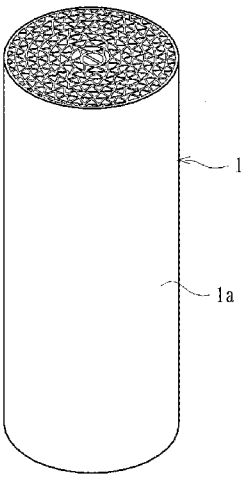
CPC ***F01N 3/2835*** (2013.01)
USPC **422/180**; 29/890

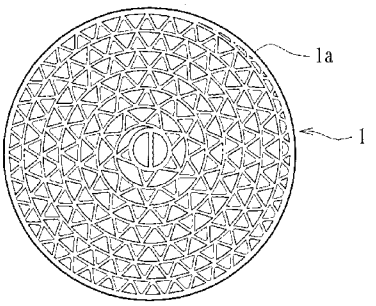
(57) **ABSTRACT**

An exhaust gas purifying catalyst device, which can have high durability against vibration and high temperatures, can be configured to suppress the peeling of the catalyst layer from the catalyst carrier member during use. Additionally, the metallic catalyst can be easily recovered after use. According to the present disclosure, an exhaust gas purifying catalyst device can comprise a catalyst carrier member on which metallic catalyst for exhaust gas purification can be carried characterized in that the catalyst carrier member can be formed of a sheet-like catalyst carrier made by a wet paper-making method, and that the metallic catalyst can be carried as a catalyst layer on surfaces of the sheet-like catalyst carrier after the sheet-like catalyst carrier has been baked.

(a)

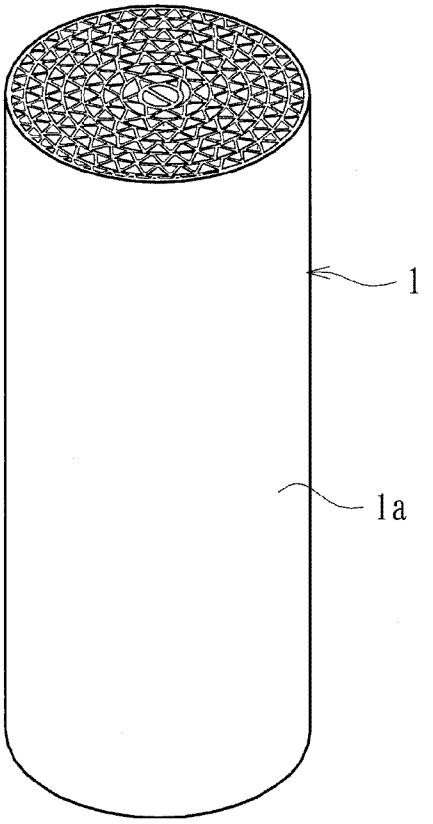


(b)



[Fig 1]

(a)



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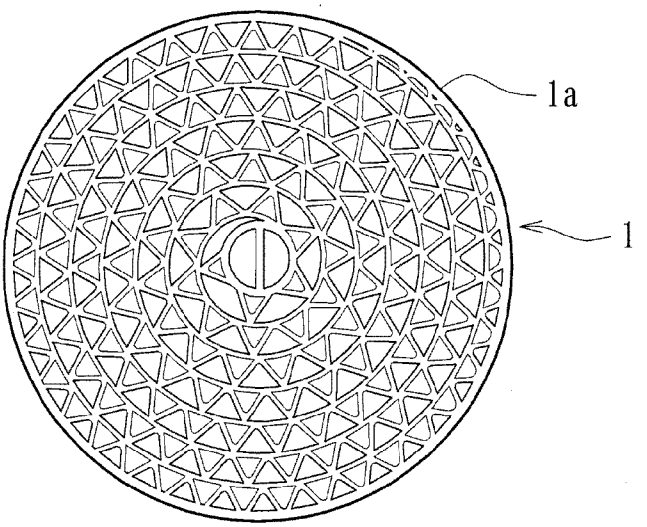
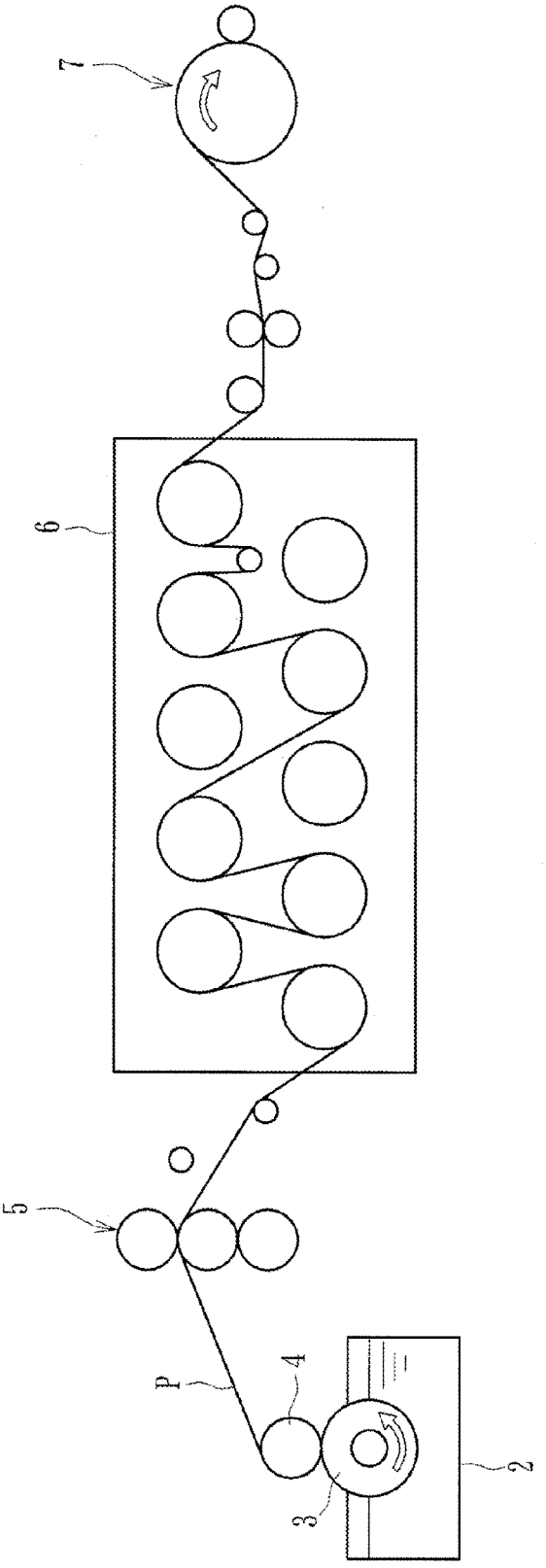
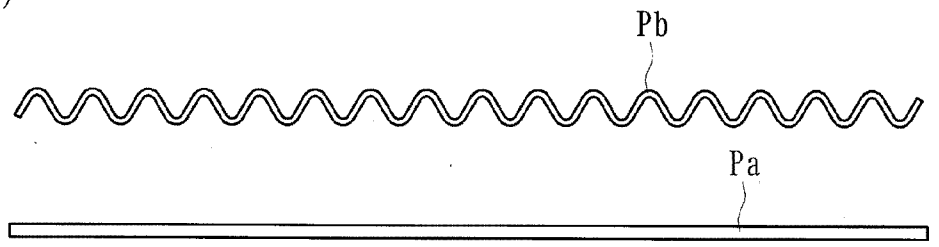




[Fig 2]

[Fig 3]

(a)



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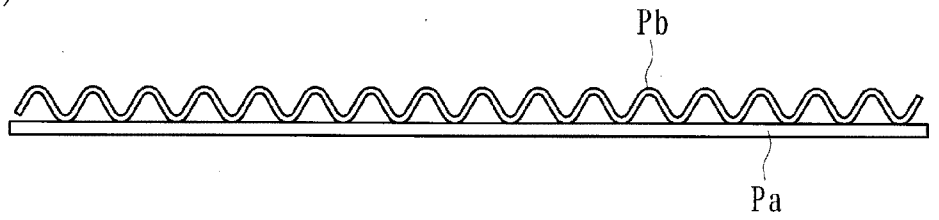

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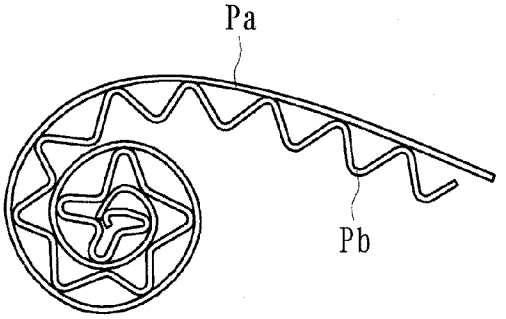
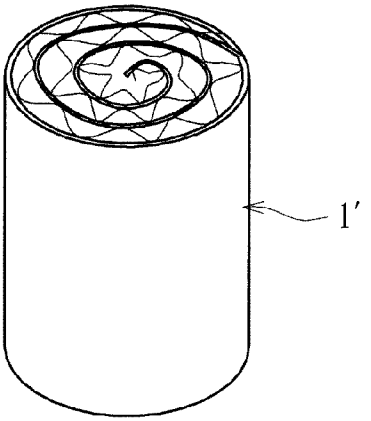
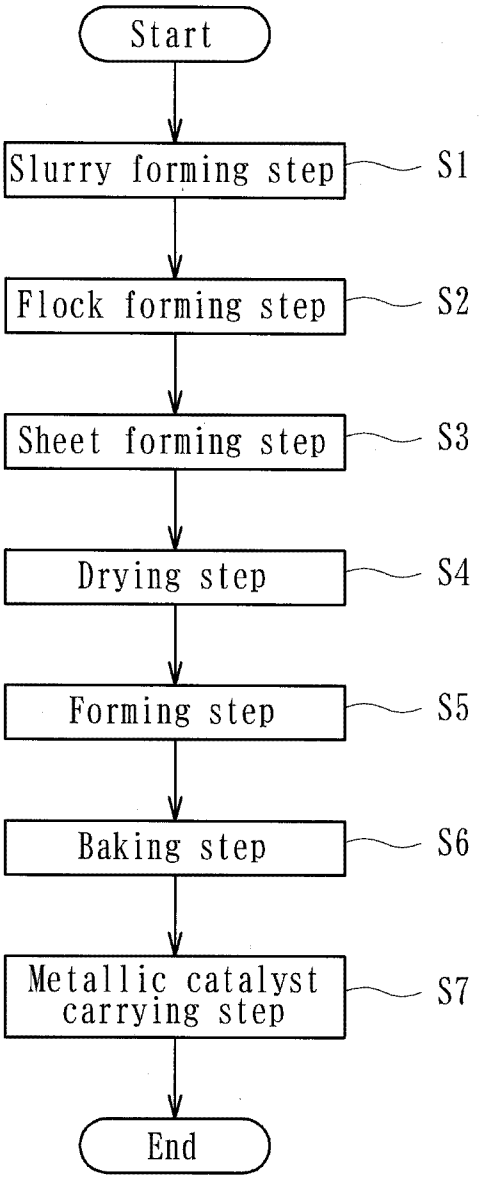


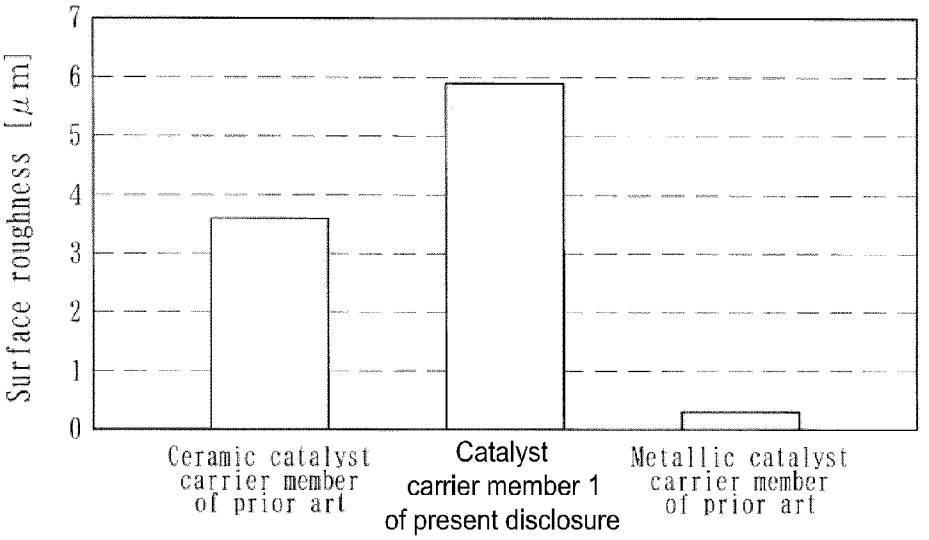
(d)



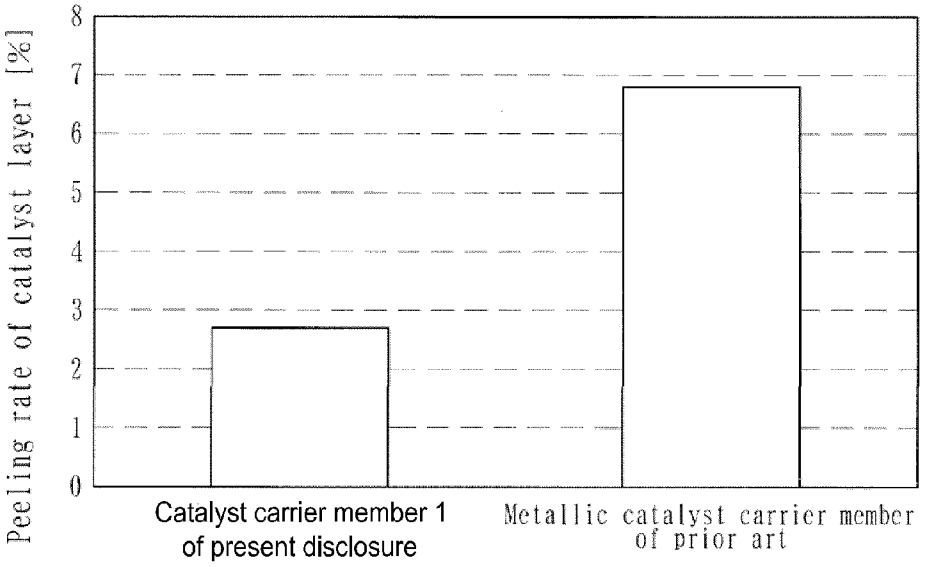
[Fig 4]


Start
Slurry forming step
S1
Flock forming step
S2
Sheet forming step
S3
Drying step
S4
Forming step
S5
Baking step
S6
Metallic catalyst carrying step
S7
End

[Fig 5]


Surface roughness [μm]
0
1
2
3
4
5
6
7
Ceramic catalyst carrier member of prior art
Catalyst carrier member 1 of present disclosure
Metallic catalyst carrier member of prior art

[Fig 6]


Peeling rate of catalyst layer [%]
0
1
2
3
4
5
6
7
8
Catalyst carrier member 1 of present disclosure
Metallic catalyst carrier member of prior art

EXHAUST GAS PURIFYING CATALYST DEVICE

INCORPORATION BY REFERENCE TO ANY PRIORITY APPLICATIONS

[0001] Any and all applications for which a foreign or domestic priority claim is identified in the Application Data Sheet as filed with the present application are hereby incorporated by reference under 37 CFR 1.57.

BACKGROUND

[0002] 1. Field of the Inventions

[0003] The present disclosure relates to exhaust gas purifying devices, for example, including a catalyst carrier member for carrying thereon a metallic catalyst for exhaust gas purification.

[0004] 2. Description of the Related Art

[0005] An exhaust gas purifying catalyst device for purifying exhaust gas from an engine of a vehicle usually comprises a catalyst carrier member for carrying a noble metal catalyst such as platinum, rhodium, or palladium. In general purpose engines such as motorcycles and portable electric generators, a metallic honeycomb structure having high durability against severe engine vibration and high exhaust gas temperatures has been used as a catalyst carrier for an applied catalyst layer.

[0006] However, in the catalyst device having the metallic honeycomb structure of the prior art noted above, the surfaces of the metallic honeycomb structure are smooth, and thus adhesiveness of the catalyst layer to the metallic honeycomb structure can be insufficient. Therefore, the catalyst layer applied on the metallic carrier could be peeled therefrom. Various means of the prior arts for suppressing the peeling of the catalyst layer from the metallic carrier have been proposed.

[0007] For example, micro projections are formed on the surfaces of the metallic honeycomb structure for gripping the catalyst layer disclosed in Japanese Applications Nos. JP 2004-169111 and JP 08-299808, or a metallic oxide coating for gripping the catalyst layer is formed on the surfaces of the metallic honeycomb structure, as disclosed in Japanese Application No. JP 06-71185.

[0008] However, in the exhaust gas purifying catalyst device of the prior art publications noted above, since it is necessary to form a means for preventing peeling of the catalyst layer (e.g. micro projections or metallic oxide coating) on the catalyst carrier member, the overall number of manufacturing steps would be increased, and thus manufacturing costs would be increased. On the other hand, although it is possible to have a catalyst device for preventing peeling or separation of the metallic catalyst from the catalyst carrier member, it is very difficult to recover the metallic catalyst when the exhaust gas purifying catalyst device is scrapped after use. This is especially true when the catalyst carrier member is made of materials other than metal having high durability against vibration or high temperature, and where the metallic catalyst is contained within the catalyst carrier member.

SUMMARY

[0009] Aspects of the present disclosure provide an exhaust gas purifying catalyst device which has high durability against vibration and high temperatures and is able to suppress the peeling of a catalyst layer from a catalyst carrier member during use. Further, the device allows for easy recover the metallic catalyst after use.

[0010] In some embodiments, an exhaust gas purifying catalyst device can comprise a catalyst carrier member on which a metallic catalyst for exhaust gas purification is carried, wherein the catalyst carrier member can be formed of a sheet-like catalyst carrier made by a wet paper-making method. The metallic catalyst can be carried as a catalyst layer on surfaces of the sheet-like catalyst carrier after the sheet-like catalyst carrier has been baked.

[0011] In some embodiments, a sheet-like catalyst carrier can include ceramic powder and alumina-silica fibers.

[0012] In some embodiments, the ceramic powder can comprise alumina.

[0013] In some embodiments, the weight ratio of the alumina-silica fibers to the ceramic powder of alumina included in the catalyst carrier member can be within a range of 0.2-2.5.

[0014] In some embodiments, the baking temperature can be within a range of 1450-1550° C.

[0015] In some embodiments, the catalyst carrier member can be manufactured through: a sheet making step for paper-making the sheet-like catalyst carrier from flock formed by adding flocculant into slurry of water mingled with fibers and binder, a baking step for baking the sheet-like catalyst carrier obtained in the sheet making step, and a metallic catalyst applying step for applying the metallic catalyst onto the surfaces of the catalyst carrier member obtained in the baking step.

[0016] In some embodiments, the catalyst carrier member can have a honeycomb structure formed by adhering a corrugated sheet-like catalyst carrier onto at least one surface of a flat sheet-like catalyst carrier, and by winding them into a roll.

[0017] According to the present disclosure, since the exhaust gas purifying catalyst device can comprise a catalyst carrier member which can be formed of a sheet-like catalyst carrier made by a wet paper-making method, and the metallic catalyst can be carried as a catalyst layer on surfaces of the catalyst carrier member after baking of catalyst carrier member, it is possible for the catalyst carrier member to have high durability against vibration and high temperatures, and to suppress the peeling of the catalyst layer from the catalyst carrier member during use. Further, the metallic catalyst can be easily recovered after use.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] FIGS. **1**A-B illustrate a schematic perspective view (A) and a plan view (B) showing an embodiment of a catalyst carrier member used for an exhaust gas purifying catalyst device of the present disclosure.

[0019] FIG. **2** illustrates a schematic view showing an embodiment of a manufacturing process of a sheet-like catalyst carrier used for making a catalyst carrier member.

[0020] FIGS. **3**A-D illustrate schematic views showing an embodiment of manufacturing steps of a honeycomb catalyst carrier member used in an exhaust gas purifying catalyst device of the present disclosure.

[0021] FIG. **4** illustrates a flowchart showing embodiments of manufacturing steps of a catalyst carrier member used in an exhaust gas purifying catalyst device of the present disclosure.

[0022] FIG. **5** illustrates a graph for comparing the surface roughness of an embodiment of a catalyst carrier member of the present disclosure and those made of ceramics and metal of the prior art.

[0023] FIG. **6** illustrates a graph for comparing a catalyst layer peeling rate of an embodiment of a catalyst carrier member of the present disclosure and that made of metal of the prior art.

DETAILED DESCRIPTION

[0024] Several embodiments of the present disclosure are described more in detail below with reference to the accompanied drawings.

[0025] The exhaust gas purifying catalyst device of the present disclosure can be used for purifying exhaust gas discharged from general purpose engines such as, for example, motorcycles and portable electric generators, and can comprise a cylindrical catalyst carrier member **1**, or catalyst carrier, having a honeycomb structure. The catalyst carrier member **1** can be manufactured by first making a sheet-like, or paper-like, catalyst carrier P using a wet paper-making method (a so-called "outturn machining method", see FIG. **2**), then by forming the obtained sheet-like catalyst carrier P into a rolled configuration having a honeycomb structure, followed by baking the rolled catalyst carrier and by applying catalyst layers on the surfaces of the rolled honeycomb carrier structure.

[0026] The method for manufacturing the exhaust gas purifying device **1** of the present disclosure is described below with reference to a flowchart of FIG. **4**.

[0027] First, an aqueous solution can be prepared by adding ceramic powder, fibers, such as heat resisting fibers including alumina-silica fibers, inorganic binder, and a pore controlling agent into water to form a slurry in which said additives can be uniformly dispersed (slurry forming step S**1**). Then, flock can be formed by adding flocculant to the slurry (flock forming step S**2**). Following, a sheet-like (paper-like) porous structure can be formed (sheet forming step S**3**) by paper making the flock (wet paper-making method).

[0028] In the present disclosure, the ceramic powder can comprise alumina, and the weight ratio of the alumina-silica fibers to the ceramic powder of alumina included in the catalyst carrier member **1** (weight ratio of the alumina-silica fibers/ceramics powder comprising alumina) can be set within a range of 0.2-2.5. According to the present disclosure, in some embodiments noble metal used as a metallic catalyst may not be contained in the raw material (water solution) used in paper-making process.

[0029] The heat resisting fibers can comprise an amorphous ceramic formed by silica and alumina as main components, and can be formed into a sheet-like catalyst carrier P by a wet paper-making method. Other heat resisting fiber materials, for example organic fibers such as Aramid fibers, may be used as well. Preferably, they are chemically and physically stable and able to obtain a strong structure of entangled fibers in the paper-making step. In addition, it is also possible to form the paper-like catalyst carrier P of glass fibers or carbon fibers. These fibers can have high heat resistance and chemically and physically stable properties after the wet paper-making method.

[0030] The flocculant for forming the flock can include high-molecular flocculant and metallic cations, and can have a strong electric charge. Thus, the flocculant can neutralize the electric charges in an aqueous solution of fibers which can be separated from each other by repulsive forces, and can force the fibers to be entangled. The high-molecular flocculant can penetrate into spaces between fibers and act to increase the binding force. Alum, aluminum sulfate, or other materials containing Al^{3+} cations in an aqueous solution can be used as metallic cations.

[0031] According to the present disclosure, a thickness of the sheet-like catalyst carrier P can be manufactured as shown in FIG. **2** by containing said flock, including fibers and binder (flock formed via the slurry forming step S**1** and flock forming step S**2**), in a containing tank **2**, and by ladling out liquid in the tank **2** using a cylinder mould **3** (e.g. a cylindrical mesh member for transferring constant amount of slurry to a roller **4**) rotated at a position near the liquid level. This sheet-like catalyst carrier P can be continuously transferred from the roller **4** to a roll press **5** and adjusted to a desired thickness by applying a pressure using the roll press **5**.

[0032] The sheet-like catalyst carrier P can be pressed by the roll press **5** into a thickness (sheet forming step S**3**), and can be continuously fed to a drying machine **6** and dried during transference therethrough (drying step S**4**). The dried sheet-like catalyst carrier P can then be continuously wound up by a winding-up machine **7**. Thus an amount of the sheet-like catalyst carrier P can be obtained. This sheet-like catalyst carrier P can then be formed into a honeycomb catalyst carrier member **1'** of porous structure by rolling a flat sheet-like catalyst carrier Pa and a corrugated sheet-like catalyst carrier together to form a honeycomb structure in a way described in detail below (forming step S**5**, see FIG. **3**). Finally, the honeycomb catalyst carrier member **1'** can be baked to form the catalyst carrier member **1** having porous structure (baking step S**6**, see FIG. **1**). In some embodiments, just after the baking step S**6**, no noble/catalyst metal has yet been applied to the catalyst carrier member **1**.

[0033] In the forming step S**5**, the sheet-like catalyst carrier P wound by the winding-up machine **7** can be prepared into two kinds of sheets; one being a flat sheet-like catalyst carrier Pa and the other being a corrugated sheet-like catalyst carrier Pb as shown in FIG. **3**(*a*). A length of the corrugated sheet-like catalyst carrier Pb can be adhered by an adhesive, or other means, to at least one surface of the straight sheet-like catalyst carrier Pa as shown in FIG. **3**(*b*). Then, adhered sheet-like catalyst carriers Pa, Pb can be wound as shown in FIG. **3**(*c*) to have a rolled honeycomb catalyst member **1'** prior to baking (FIG. **3**(*d*)).

[0034] The honeycomb catalyst carrier member **1** (FIG. **1**) can be obtained by baking the honeycomb catalyst member **1'** (FIG. **3**(*d*)) obtained in the forming step S**5** e.g. at a temperature of 1450-1550° C. (baking step S**6**). FIG. **5** shows comparative results of the surface roughness of an embodiment of a honeycomb catalyst carrier member **1** manufactured in accordance with the present disclosure, a ceramic honeycomb catalyst carrier member of the prior art, and a metallic honeycomb catalyst carrier member of the prior art. As can be seen from FIG. **5**, the surface roughness of the honeycomb catalyst carrier member **1** of the present disclosure is about 5.916 (μm) (a central graph in FIG. **5**) and on the other hand, those values of the ceramic honeycomb catalyst carrier member and the metallic honeycomb catalyst carrier member of the prior art are about 3.576 (μm) (a left side graph in FIG. **5**) and about 0.227 (μm) (a right side graph in FIG. **5**) respectively. As shown, the surface roughness of embodiments of a honeycomb catalyst carrier member **1** of the present disclo-

sure is larger than those of the ceramic and metallic honeycomb catalyst carrier member of the prior art.

[0035] The surface **1***a* of the honeycomb catalyst carrier member **1** obtained through the baking step S**6** can then be formed with a catalyst layer to carry thereon the metallic catalyst of noble metals (e.g. platinum, rhodium, palladium, or other noble metals) (metallic catalyst carrying step S**7**). In the metallic catalyst carrying step S**7**, the slurry, including the metallic catalyst and the binder, can be applied to the surface **1***a* of the honeycomb catalyst carrier member **1** obtained through the baking step S**6**, and the honeycomb catalyst carrier member **1** can be heat treated at about 600° C. to solidify the binder and thus to secure the catalyst layer on the surface **1***a* of the honeycomb catalyst carrier member **1**.

[0036] The honeycomb catalyst carrier member **1** of the present disclosure can be technically advantageous over the metallic catalyst carrier member of the prior art. Samples (outer diameter: 30 mm, length 20 mm) of embodiments of a honeycomb catalyst carrier member **1** of the present disclosure and the metallic catalyst carrier member of the prior art were made, and the slurry, including the metallic catalyst (noble metals as catalyst) and the binder, were applied to the surfaces of samples and both samples were heat treated at about 600° C. to solidify the binder and thus to secure the catalyst layer on the surfaces of the samples.

[0037] The weight of the catalyst layer applied onto the surface of the catalyst carrier member of the present disclosure was 1.3572 (g) and that of the catalyst carrier member of the prior art was 2.0414 (g).These weights were obtained by calculating the weight of the catalyst layer by measuring differences in weight of the samples before and after the application of slurry and the heat treatment. Then both the samples were held in an electric furnace at 1000° C. for 10 minutes and taken out therefrom and cooled to a room temperature.

[0038] A peeling test was performed by immersing both samples into a water tank of an ultrasonic vibrator (180 W, 42 Hz) and holding them in the water tank under application of ultrasonic vibration. This peeling test was repeated five times, and the peeling rate of the catalyst layer was calculated from weight variation before and after the peeling tests. As shown in FIG. **6**, the peeling rate of the catalyst layer of the catalyst carrier member **1** of the present disclosure was 2.61% and that of the metallic catalyst carrier member of the prior art was 6.71%. It can be found that the catalyst layer of the catalyst carrier member **1** of the present disclosure is able to remarkably reduce the peeling rate of the metallic catalyst layer as compared with that of the metallic catalyst carrier member of the prior art.

[0039] According to the present disclosure, since the metallic catalyst layer can be carried on rough surfaces of the catalyst carrier member **1** formed of baked sheet-like catalyst carriers P (Pa, Pb) made by the wet paper-making method, it is possible to make an exhaust gas purifying catalyst device which has excellent durability against vibration and heat and is able to suppress peeling of the catalyst layer during use. Further, the metal catalyst can be easily recovered after use. That is, since the catalyst carrier member **1** of the present disclosure can be formed of sheet-like catalyst carriers P made by the wet paper-making method, and thus the surfaces of the catalyst carrier member **1** are roughened by fibers, the catalyst layer applied on the surfaces of the catalyst carrier member **1** can be held thereon for a long term.

[0040] In addition, since the catalyst carrier member **1** can be manufactured through a sheet making step S**3** for paper-making the sheet-like catalyst carrier P from flock formed by adding flocculant into slurry of water mingled with fibers and binder; a baking step S**6** for baking the sheet-like catalyst carrier P obtained in the sheet making step S**3**; and a metallic catalyst applying step S**7** for applying the metallic catalyst onto the surfaces of the catalyst carrier member **1** obtained in the baking step S**6**, it is possible to have the exhaust gas purifying catalyst device which has excellent durability against vibration and heat, and is able to suppress peeling of the catalyst layer during use. Further, the metal catalyst can be easily recovered after use.

[0041] Furthermore, since the catalyst carrier member **1** can have a honeycomb structure formed by adhering a corrugated sheet-like catalyst carrier Pb onto at least one surface of a flat sheet-like catalyst carrier Pa and by winding them Pa, Pb to a roll, it is possible for the honeycomb structure to pass the flow of exhaust gas through the inside of the catalyst carrier member **1** and thus to perform the exhaust gas purifying operation. In addition, since the baking temperature can be within a range of 1450-1550° C. according to the present disclosure, it is possible to perform a perfect baking while avoiding melting of the catalyst carrier member **1** during the baking step S**6**.

[0042] The present disclosure has been described with reference to several embodiments. Obviously, modifications and alternations will occur to those of ordinary skill in the art upon reading and understanding the preceding detailed description. It is intended that the present disclosure be construed as including all such alternations and modifications insofar as they come within the scope of the appended claims or the equivalents thereof. For example, the noble metals to be carried in the metallic catalyst applying step S**7** may be other catalyst metals than platinum, rhodium and palladium. In addition, the sheet-like catalyst carrier P may be formed of other materials than ceramic powder and alumina-silica fibers, and ceramic powder other than alumina may be used. Furthermore, the weight ratio of the alumina-silica fibers to the ceramic powder of alumina included in the catalyst carrier member **1** may be other weight ratio than a range of 0.2-2.5.

[0043] The present disclosure can be applied to other types of exhaust gas purifying device than that for a vehicle so long as it is formed of the sheet like catalyst structure on which surfaces metallic catalyst is carried by forming the catalyst layer after baking the sheet like catalyst structure made by the wet paper-making method.

What is claimed is:

1. An exhaust gas purifying catalyst device comprising:

a catalyst carrier member on which metallic catalyst for exhaust gas purification is carried;

wherein the catalyst carrier member is formed of a sheet-like catalyst carrier made by a wet paper-making method; and

wherein the metallic catalyst is carried as a catalyst layer on surfaces of the sheet-like catalyst carrier after the sheet-like catalyst carrier has been baked.

2. An exhaust gas purifying catalyst device of claim **1**, wherein the sheet-like catalyst carrier comprises ceramic powder and alumina-silica fibers.

3. An exhaust gas purifying catalyst device of claim **1**, wherein the ceramic powder comprises alumina.

4. An exhaust gas purifying catalyst device of claim **3**, wherein the weight ratio of the alumina-silica fibers to the ceramic powder of alumina is within a range of 0.2-2.5.

5. An exhaust gas purifying catalyst device claim **1**, wherein the baking temperature is within a range of 1450-1550° C.

6. An exhaust gas purifying catalyst device of claim **1**, wherein the catalyst carrier member is manufactured through a sheet making step for paper-making the sheet-like catalyst carrier from flock formed by adding flocculant into slurry of predetermined amount of water mingled with predetermined fibers and binder; a baking step for baking the sheet-like catalyst carrier obtained in the sheet making step; and a metallic catalyst applying step for applying the metallic catalyst onto the surfaces of the catalyst carrier member obtained in the baking step.

7. An exhaust gas purifying catalyst device of claim **1**, wherein the catalyst carrier member has a honeycomb structure formed by adhering a corrugated sheet-like catalyst carrier onto at least one surface of a flat sheet-like catalyst carrier and by winding them to a roll.

8. A method for forming an exhaust gas purifying catalyst device comprising:

manufacturing a sheet-like catalyst carrier from flock through a wet paper-making step;

baking the sheet-like catalyst carrier; and

applying a metallic catalyst to the surface of the baked sheet-like catalyst carrier.

9. A method of claim **8**, wherein the sheet-like catalyst carrier comprises ceramic powder and alumina-silica fibers.

10. A method of claim **9**, wherein the ceramic powder comprises alumina.

11. An exhaust gas purifying catalyst device of claim **10**, wherein the weight ratio of the alumina-silica fibers to the ceramic powder of alumina is within a range of 0.2-2.5.

12. A method of claim **8**, wherein the baking temperature is within a range of 1450-1550° C.

* * * * *