Title: A SINTERED PRODUCT

Abstract: The present invention relates to sintered products comprising a set of short metal fibers. The set of short metal fibers comprises fibers having a diameter ranging between 1 and 150 µ. The set comprises entangled and curved fibers. The invention further relates to a method of manufacturing a sintered product comprising short metal fibers and to the use of a sintered product for example as filtering device, as carrier for a catalyst or as heat exchanging device.
A SINTERED PRODUCT

Field of the invention.
The invention relates to sintered products comprising short metal fibers.
The invention further relates to a method of manufacturing a sintered product comprising short metal fibers and to the use of a sintered product for example as filtering device, as carrier for a catalyst, as heat exchanging device or as mould.

Background of the invention.
Sintered products comprising metal powder particles are known in the art. Also sintered products comprising metal fibers, with a length of several centimeters are also known in the art.
However, it is extremely difficult, if not impossible to provide a sintered three-dimensional structure in an economical way.
Furthermore these sintered products feature the drawback to have a limited porosity and thus a high pressure drop.

Metal fibers having a rather flat cross section, with diameter less than 15 \( \mu m \) and a length of less than 400 \( \mu m \) are known from US4703898. These fibers have a crescent shape and have a small, point-like hook at both ends. This document further provides a method to produce such fibers. JP2175803 describes similar short metal fibers, which have a curved shape.

Short metal fibers are also known from GB889583. These metal fibers may be undulated or "kinked" over their length. In this document, these terms mean that the major axis of the fibers change two or more times over the length of the fiber.
GB889583 also describes sintered products comprising metal fibers.
However, since the metal fibers described in this document have a very poor pouring behavior, sintered products can not be manufactured in an economical way.
Summary of the invention.
It is an object of the present invention to provide sintered products comprising short metal fibers characterised by a high porosity.
It is another object to provide sintered products having isotropic properties over the whole volume of the sintered products.
It is also an object to provide a method for manufacturing sintered products comprising short metal fibers.
It is a further object to provide the use of a sintered product according to the present invention for example as filtering device, as catalytic carrier or as heat exchanging device.

According to a first aspect of the present invention a sintered product comprising a set of short metal fibers is provided.

The set of short metal fibers used to manufacture a sintered product is characterized by the presence of two different groups of short metal fibers: "entangled" fibers and "curved" fibers.

A set of short metal fibers as subject of the invention comprises short metal fibers with an equivalent diameter D between 1 and 150 μm. More preferably, the equivalent diameter is between 2 and 100 μm. Most preferably, the equivalent diameter ranges between 2 and 50 μm or even between 2 and 35 μm such as 2, 4, 6.5, 8, 12 or 22 μm.

With the term "equivalent diameter" is meant the diameter of an imaginary circle, which has the same surface as the surface of a fiber, cut perpendicular to the major axis of the fiber.

The set of short metal fibers comprises entangled fibers. The number of entangled fibers in a set of short metal fibers as subject of the invention ranges from 5 to 35 %. Preferably, more than 10% of all short metal fibers in the set of short metal fibers are entangled fibers. These fibers are hereafter referred to as "entangled fibers".
To have a statistically reliable percentage, a sample of at least 50 fibers, randomly chosen out of the set of short metal fibers are to be evaluated.

The percentage of entangled fibers is measured and calculated as:

\[
\text{% entangled fibers} = 100 \times \frac{\# \text{entangled}}{\# \text{total}}
\]

wherein

\# entangled : number of entangled fibers out of the sample;

\# total : number of fibers out of the sample.

The entangled fibers of the set of short metal fibers as subject of the invention have a length which is considerably longer than the length of the curved fibers. The average length of the entangled fibers \( L_e \) is at least 5 times the average length of the curved fibers \( L_c \). Preferably, the average length of the entangled fibers \( L_e \) is more than 10 times the average length of the curved fibers \( L_c \).

Preferably, the average length of the entangled fibers \( L_e \) is larger than 200 \( \mu \text{m} \), or even more than 300 \( \mu \text{m} \), most preferably more than 1000 \( \mu \text{m} \). An entangled fiber may be entangled with itself (individually entangled) or an entangled fiber may be entangled together with some other entangled fibers. The entangled fibers, either individually or together with other entangled fibers, cannot be individualised as an essentially straight fiber out of the shape which is defined by the entanglement of the fibers. The major axis of each fiber changes so often and unpredictably, that the fiber may be entangled in many different ways. Some of the fibers are present in a shape, which resembles a clew. The effect is comparable to the so-called pilling effect, well known in the textile industry, and in carpet industry more in particular. One or more fibers get trapped into a small ball. The trapped fibers may not be separated from this ball anymore. Other fibers look more like a pigtail. They are characterized by a major axis which
changes several times in an unpredictable way, so a relatively chaotic shape may be provided.

The other short metal fibers out of the set of short metal fibers are hereafter referred to as "curved fibers".

The average length of the curved fibers \( L_c \) of the set of short metal fibers may range from 10 to 2000 \( \mu \text{m} \), preferably from 30 to 1000 \( \mu \text{m} \) such as 100 \( \mu \text{m} \), 200 \( \mu \text{m} \) or 300 \( \mu \text{m} \). When a length distribution is measured from these curved fibers as part of a set of short metal fibers, a gamma-distribution is obtained. This gamma-distribution is identified by an average length \( L_c \) and a shape factor "\( S \)". According to the present invention, the gamma-distribution of the length of the curved fibers, has a shape factor \( S \) ranging between 1 and 10.

For average lengths \( L_c \) larger than 1000 \( \mu \text{m} \), usually a shape factor \( S \) larger than 5 is measured. For average lengths \( L_c \) between 300 \( \mu \text{m} \) and 1000 \( \mu \text{m} \), usually a shape factor \( S \) between 2 and 6 is measured. For average lengths \( L_c \) smaller than 300 \( \mu \text{m} \), usually a shape factor \( S \) smaller than 3 is measured. To have a statistically reliable distribution, at least 50 curved fibers, randomly chosen out of the set of short metal fibers are to be measured.

The \( L/D \) ratio of a set of short metal fibers as subject of the invention has a \( L/D \)-ratio of more than 5, preferably more than 10, wherein \( L \) is the average length of all fibers, present in a representative sample of fibers from the set of short metal fibers. As described above, this sample comprises at least 50 fibers out of the set of short metal fibers. Preferably, but not necessarily, the curved fibers out of a set of short metal fibers as subject of the invention has an \( L_c/D \)-ratio of more than 5, preferably more than 10.

Further, a majority of these curved fibers have a major axis, which changes over an angle of at least 90°. This angle is the largest angle
which can be measured between two tangents of this major axis. Preferably, 40% of the curved fibers has a major axis, changing more than 90°, e.g. more than 45%, or preferably more than 50%. To measure these curves of the major axis, a microscopic image with appropriate enlargement is taken from several short metal fibers. Using a computer imaging system, the tangents of the major axis and the largest angle between them is calculated. To have a statistically reliable sample, at least 50 curved fibers, randomly chosen out of the set of short metal fibers are to be measured.

A set of short metal fibers used to manufacture a sintered product according to the present invention has several advantages. Such a set of short metal fibers has for example good pouring behavior.

Further, when these short metal fibers are poured, e.g. in a specific three-dimensional mould or on a flat surface, numerous contact points can be noticed between the short metal fibers. They are, so to say, ready to be sintered. If a product with a high porosity, i.e. a porosity higher than 80% is desired, it is not necessary to apply a force before sintering. A high number of contact points is present without requiring a force. This is not the case when the diameter of the short metal fibers extends beyond 150 µm.

One understands that, if it is necessary to increase even more the number of contact points, or to decrease the pore volume and/or size, such forces may be applied before or during further processing.

Once poured, a set of short metal fibers as subject of the invention has an apparent density in the range of 10 to 40%, according to ISO 787-11. The pores between the short metal fibers are very small, but the number of pores is sufficiently large to provide an apparent density which is typically between 10 and 40%. The porosity, calculated as indicated below, ranges between 60 and 90%.
Porosity (%) = 100% - apparent density (%)

The volumes between the fibers are similar throughout the poured volume, so providing an isotropic volume.

Short metal fibers used to manufacture a sintered product may be obtained by a method comprising the following steps:
- Individualizing the metal fibers by a carding operation;
- Providing the set of short metal fibers by cutting or entangling and by sieving the set of short metal fibers, preferably by using a comminuting machine.

First, metal fibers, being present in a bundle of fibers, in a yarn or a textile structure, or even as staple fibers, are individualized to some extend by a carding operation. These more or less individualized fibers are brought into a comminuting device. In this device, each fiber is cut into short metal fibers by fast rotating knives. The blade of these knives, having a certain blade thickness, encounter or 'hit' the fibers usually in radial direction. The fibers are mechanically plastically deformed and entangled or possibly broken into a smaller length. Due to the centrifugal force, the so provided short metal fibers (curved or entangled) are blown outwardly against the external wall of the comminuting device. This external wall comprises a sieve with well-defined openings. According to these openings, short metal fibers with a certain length may pass through the sieve, whereas too long short metal fibers will stay in the comminuting device and possibly be hit once again, until the lengths are sufficiently small to pass the sieve, or until they are entangled enough to allow passage through the sieve.
According to a second aspect of the present invention a method of manufacturing a sintered product is provided. The method comprises the steps of
- providing a set of short metal fibers;
- pouring said set of short metal fibers into a three-dimensional mould or on an essentially plane surface;
- sintering said set of short metal fibers to form a sintered product.

Possibly, before the sintering, the short metal fibers are pressed together to improve the coherency and/or to change the density.

Alternatively, the short metal fibers are brought in a suspension, using an appropriate agent or a mixture of appropriate agents. The suspension is brought into a mould or poured onto an essentially plane surface. In a subsequent step the suspension liquid is removed, e.g. evaporated or sucked out. The mould, comprising the short fibers is then subjected to a sintering process in which all non-metal fiber elements are removed and in which a sintering between the metal fibers is obtained.

The sintering conditions are dependent upon the alloy and the properties required by the short metal fibers and the final sintered product.

A great advantage of the method of the present invention is that the set of short metal fibers can easily be poured homogeneously; resulting in isotropic properties over the whole volume of the product. For example the density and the sizes of the pores are homogeneous over the whole volume of the product.

Another advantage of sintered products according to the present invention is their high porosity.
As indicated above, the short metal fibers will arrange themselves providing a three dimensional fiber structure, with numerous small pores and numerous contact points. The pores are characterized by a relatively small size.

Applying forces on the short metal fibers during sintering may decrease pore size and porosity.

The porosity of a sintered product according to the invention is equal to the porosity of the poured fibers, as described above. The fibers do not have to be put under pressure to form a coherently sintered volume. This means that the porosity ranges generally between 60 and 90%. The porosity is for example 70, 80 or 85%. However, dependent on the type and level of pressure, the porosity may be lowered to 49% if necessary, for example by cold isostatic pressing.

According to the specific use of the sintered metal fiber product, different metals and/or alloys may be used to provide the short metal fibers or the sintered metal fiber product.

The alloy of the metal fibers is to be chosen in order to provide the required properties such as temperature resistance or electrical conductivity. Stainless steel fibers out of AISI 300-type alloys, e.g. AISI 316L or fibers based on INCONEL®-type alloys such as INCONEL®601 or Nicrofer®- type alloys such as Nicrofer® 5923 (hMo Alloy 59) and Nicrofer 6023, or fibers based on Fe-Cr-Al alloys may be used. Also Ni-fibers, Ti- fibers, Al-fibers, Cu-fibers or fibers out of Cu-alloy or other alloys may be used.

Metal fibers may e.g. be bundle drawn or shaved, or provided by any other process as known in the art.

Sintered products comprising short metal fibers may have different shapes, according to the specific requirements of their application.
Sintered products may for example be sintered into flat plates, rings, cylindrical or tube like shapes. Also more complex shapes such as monolithic structures may be obtained.

Sintered short metal fibers products may be used for different applications.

They may be used as a filtering device, for example a filtering device to filter gases or liquids.

The alloy of the metal fibers may be chosen in order to provide the filtering device the required properties such as temperature resistance and chemical resistance. Consequently, the filtering device may be used for high temperature applications, for example for the filtration of hot gases or for the filtration of corrosive gases or liquids.

The filtering device may have any shape. Preferred shapes are flat plates, rings, or cylindrical or tube like shapes.

When a sintered product as subject of the invention is used as a filtering device, especially after being isostatically pressed, such filtering device may have an absolute filter rating of 0.5 μm up to 20 μm. Usually, the absolute filter rating may range between 1/3 and 1/2 of the equivalent diameter of the short metal fibers used.

A filtering device according to the present invention can thus be used for microfiltration applications, for example for the filtration of air in clean labs or in production rooms of electronic components.

A sintered product according to the present invention is in particular suitable to be used to filter diesel exhaust gasses.
A sintered products as subject of the present invention may also be used as a carrier for catalysts. Therefore, commercially available catalyst can be applied on a sintered product.

A sintered product on which a catalyst is applied, hereinafter referred to as the catalyst, can be used to treat exhaust gases such as exhaust gases from incinerators or diesel engines, thereby removing harmful substances, such as NOₓ, NH₃, CO, dioxins, O₃.

The catalyst is characterised by a porous open structure and a high specific surface. At the same time it is characterised by a high strength.

Since the sintered product may withstand high temperatures, the catalyst can be used at high operating temperatures.

All these features result in a catalyst having a high efficiency of catalytic conversion.

Furthermore, a sintered product according to the present invention may be used as a catalytic filter which combines particle and/or dust retention and catalytic conversion of harmful components.

Sintered short metal fibers products may also be used as heat exchanging device. e.g. in Stirling engines, where a sintered short metal fibers product may be mounted in the passage of the working fluid or gas. Such device is also referred to as heat recuperator. The sintered short metal fiber product is heated when the working fluid or gas passes from the hot to the cold chamber of the Stirling engine. Afterwards, the heat, captured in the sintered short metal fibers product is regenerated when the cold working fluid or gas passes again through the sintered short metal fibers product, while it flows back to the hot chamber of the Stirling engine.

**Brief description of the drawings.**

The invention will now be described into more detail with reference to the accompanying drawings wherein
-FIGURES 1A, 1B, 1C, 1D, 1E and 1F are images of short metal fibers, all being part of a set of short metal fibers used to manufacture a sintered product according to the present invention;

-FIGURE 2 shows a curved fiber being part of a set of short metal fibers;

-FIGURE 3 shows a graph of the length distribution of a set of short metal fibers;

-FIGURE 4 shows a graph of the curvature distribution of the curved fibers out of a set of short metal fibers;

-FIGURE 5 shows a sintered product as subject of the invention having the shape of a ring;

-FIGURE 6a and 6b show a sintered product having a monolithic structure.

Description of the preferred embodiments of the invention.

A preferred embodiment of a set of short metal fibers used to manufacture a sintered product as subject of the invention is shown in FIGURES 1A, 1B, 1C, 1D, 1E and 1F. All the shown short metal fibers are out of the same set of short metal fibers.

The short metal fibers, having an equivalent diameter of 22 µm, are obtained by providing a bundle of AISI 316L bundle drawn fibers which are individualized to some extent in a carding device and which are cut into short metal fibers in a comminuting device. As may be seen from FIGURE 1A to 1F, the shape of the short metal fibers may be very different. Some short metal fibers are clearly entangled fibers, such as fibers 11, 12 and 13. Fibers 12 are more curled irregularly, providing a non-defined shape. Fibers 13 are individually entangled to a non-defined shape. Fibers 11, 12 and 13 are to be understood as "entangled fibers". Other fibers 14 are clearly curved, although the curving angles are unpredictable. Some curved fibers, such as fiber 15, may have a limited curvature. An example of such a curved fiber is shown schematically in FIGURE 2. A curved fiber has two ends, being a first
end 21 and a second end 22. A major axis 23 connects the center of the transversal cuts over the whole length of the fiber. The direction of the major axis 23 changes over an angle $\alpha$. Angle $\alpha$ is the absolute value of the largest angle which can be measured between two vectors 24 having a direction equal to the tangent of the major axis, starting point being a point of the major axis, and a sense pointing from first end 21 to second end 22.

FIGURE 3 shows the angle distribution of the change of the major axis of the curved fibers of the set of short metal fibers from FIGURES 1A to 1F. A sample of 316 fibers, randomly chosen out of the total set of short metal fibers was taken. Each bar 33 in the graph represents the number of fibers (to be read at the left ordinate 34), having a major axis changing with an angle $\alpha$, $\alpha$ being smaller than the angle value underneath the bar, which is related to that bar, but larger than the angle, related to the bar at its left side. E.g. the bar related to 90°, indicates the number of curved fibers, having an angle $\alpha$ smaller than 90°, but larger than 80°. Related numbers are summarised in Table I.
Table I

<table>
<thead>
<tr>
<th>Angle $\alpha$ of fibers</th>
<th>number in sample</th>
<th>% curved with angle $\alpha$ / total curved fibers</th>
<th>% curved with angle $\alpha$ or entangled / total fibers</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>10</td>
<td>2</td>
<td>0.65</td>
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<tr>
<td>20</td>
<td>3</td>
<td>0.97</td>
<td>0.83</td>
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<tr>
<td>30</td>
<td>10</td>
<td>3.24</td>
<td>2.77</td>
</tr>
<tr>
<td>40</td>
<td>16</td>
<td>5.18</td>
<td>4.43</td>
</tr>
<tr>
<td>50</td>
<td>16</td>
<td>5.18</td>
<td>4.43</td>
</tr>
<tr>
<td>60</td>
<td>19</td>
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</tr>
<tr>
<td>70</td>
<td>22</td>
<td>7.12</td>
<td>6.09</td>
</tr>
<tr>
<td>80</td>
<td>21</td>
<td>6.80</td>
<td>5.82</td>
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<td>90</td>
<td>18</td>
<td>5.83</td>
<td>4.99</td>
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<td>17</td>
<td>5.50</td>
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</tr>
<tr>
<td>110</td>
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<td>160</td>
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<tr>
<td>entangled</td>
<td>52</td>
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<tr>
<td>total entangled</td>
<td></td>
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<td>total curved</td>
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</tr>
<tr>
<td>total</td>
<td></td>
<td>361</td>
<td></td>
</tr>
</tbody>
</table>

Line 31 indicates the cumulative curve of the number of curved fibers having an angle $\alpha$, less than the angle value in abscissa. This number is expressed, as indicated on the right ordinate 35, in percentage compared to the total number of curved fibers in the sample. More than 50% of the curved fibers have a major axis direction changing more than 90°.
As also indicated in FIGURE 3, more than 10% of all short metal fibers out of the set of short metal fibers are entangled fibers. This is indicated by the dots 32, which represent the percentage of fibers, also to be read on the right ordinate 35, comprised in the related bar 33, compared to the total number of short metal fibers out of the sample taken from the set of short metal fibers.

FIGURE 4 shows the length distribution of the curved fibers of two sets of short metal fibers as subject of the invention.

A first length distribution 41, indicated with black bars, is a length distribution of the curved fibers of a set of short metal fibers, having an equivalent diameter of 8 μm. The set of short metal fibers was provided using bundle drawn stainless steel fibers, alloy AISI 302. A representative and randomly chosen sample of 227 fibers was taken. An average length of 420 μm was found. The length distribution is a gamma-distribution 42, being characterized with a shape factor S being 3.05. The bars of distribution 41 is to be understood as the percentage of curved fibers out of the sample (read in ordinate 43), which has a length (expressed in μm and indicated in abscissa 44) in the range with upper limit as indicated underneath the bar, and lower limit being the length indicated under the adjacent bar left if it. In the same way, the gamma-distribution reads the percentage of fibers in ordinate 43 in the range indicated on the abscissa 44 as explained above.

Another length distribution 45 is shown in FIGURE 4, indicated with white bars, which is a length distribution of the curved fibers of a set of short metal fibers, having an equivalent diameter of 12 μm. The set of short metal fibers was provided using bundle drawn stainless steel fibers, alloy AISI 316L. A representative and randomly chosen sample of 242 fibers was taken. This length distribution accords to a gamma-distribution 46, which is characterized with a shape factor S being 3.72. An average length Lc of the curved fibers of 572 μm was measured.
A sintered product as subject of the invention is shown in FIGURE 5. The short metal fibers used have a diameter of 22 μm. The thickness 51 of the medium is approximately 40 mm. The sintered metal fiber product has a porosity of 81%. The short metal fibers were stainless steel bundle drawn fibers, Fecralloy® type alloy. Such ring-like shape may be used as heat exchanging device in a Stirling engine.

An alternative sintered metal fiber product, as subject of the invention is obtainable by sintering short metal fibers as subject of the invention to a flat shape or plate-like product. E.g. short metal fibers of alloy AISI 444, having an average length of 1000 μm and an equivalent diameter of 65 μm, obtained by a shaping process as explained in WO9704152, are sintered to a flat volume with thickness of 2.35 mm and a weight of 5226 g/m². A porosity of 72% and an absolute filter rating of 92 μm was obtained.

A similar product comprising bundle drawn short metal fibers having an equivalent diameter of 12 μm and an average length L of 800 μm, isostatically pressed using 800 bar, has a porosity of 70% and an absolute filter rating of 5.3 μm.

One understand that other shapes, such as flat plates, or tube-like or cylindrical shapes may be obtained. Even monolithic structures, e.g. to be used in a diesel exhaust filter, filtering soot from the exhaust gas, may be obtained.

Figure 6a shows a monolithic structure 600 comprising a set of short metal fibers. Figure 6b shows a cross-section along line A-A'. The monolithic structure shown in Figure 6 is in particular suitable to filter exhaust gases.
The gas to be filtered enters the monolithic structure at inlet side 602 and exits the monolithic structure at outlet side 604.

The monolithic structure has a number of cells 606. Each cell has a first end adjacent the inlet of the monolithic structure and a second end adjacent the outlet of the monolithic structure.

At least part of the cells is blocked at the second ends of the cell by a barrier 607. The barrier comprises a material that does not allow the passage of the gaseous stream.

In the preferred embodiment of Figure 6 a cell is either blocked at its inlet side as for example cell 608; or at its outlet side as for example cell 610.

Thus, the exhaust stream can not pass freely through the cells, but is obliged to pass through the walls to a neighbouring cell having an open outlet side.

For example exhaust gas entering cell 610 passes through the wall surrounding cell 610, as indicated by the arrows 612, for example to cell 608 through which it can leave the monolithic structure at the outlet side.

Possibly, the cell walls are coated with a catalyst or alternatively a catalyst is applied into the porous structure of the monolithic structure.

A three-dimensional sintered product according to the present invention can also be used a porous mould, for example as a mould to form glass products such as windshield glass.
CLAIMS

1. A sintered product comprising a set of short metal fibers, said short metal fibers having an equivalent diameter D in the range of 1 to 150 μm, said set of short metal fibers comprising curved fibers and entangled fibers, said curved fibers having an average length Lc in the range of 10 to 2000 μm.

2. A sintered product according to claim 1, wherein said entangled fibers have an average length Le which is at least 5 times the average length of the curved fibers Lc.

3. A sintered product according to claim 1 or 2, wherein the lengths of said curved fibers are distributed according to a gamma-distribution.

4. A sintered product according to any one of the preceding claims, wherein at least 10 % of said set of short metal fibers are entangled fibers.

5. A sintered product according to any one of the preceding claims, wherein the length to diameter ratio L/D is larger than 5; L being the average length of the short metal fibers in said set of short metal fibers.

6. A sintered product according to any one of the preceding claims, wherein the length to diameter ratio Lc/D is larger than 5; Lc being the average length of the curved metal fibers in said set of short metal fibers.

7. A sintered product according to any one of the preceding claims, wherein said short metal fibers are stainless steel fibers.
8. A sintered product according to any one of the preceding claims, wherein said curved fibers have a major axis, said major axis having a direction, said direction changing more than 90° for at least 40% of said curved fibers.

9. A sintered product according to any one of the preceding claims, wherein said product has a porosity of more than 60%.

10. A sintered product according to any one of the preceding claims, wherein said product has an absolute filler rating between 0.5 and 20 µm.

11. A sintered product according to any one of the preceding claims wherein said product has an absolute filter rating ranging between 1/3 and 1/2 of the equivalent diameter of said short metal fibers.

12. A method of manufacturing a sintered product according to any one of claims 1 to 11, said method comprises the steps of
- providing a set of short metal fibers;
- pouring said set of short metal fibers into a three-dimensional mould or on an essentially plane surface;
- sintering said set of short metal fibers to form a sintered product.

13. A method according to claim 12, whereby said method further comprises the step of pressing said short metal fibers together before performing said sintering step.

14. Use of a sintered product according to any one of claims 1 to 11 as a filtering device.

15. Use of a sintered product according to any one of claims 1 to 11 as a filtering device for filtering diesel exhaust gas.
16. Use of a sintered product according to any one of claims 1 to 11 as a carrier for a catalyst.

17. Use of a sintered product according to any one of claims 1 to 11 as a heat exchanging device.

18. Use of a sintered product according to any one of claims 1 to 11 as a heat exchanging device for a Stirling engine.

19. Use of a sintered product according to any one of claims 1 to 11 as mould.
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER

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According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

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Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (names of data base and, where practical, search terms used)

WPI Data, EPO-Internal, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
<thead>
<tr>
<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
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Date of the actual completion of the International search:

15 April 2002

Date of mailing of the international search report:

25/04/2002

Name and mailing address of the ISA

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