

Composite material comprising soft carbon fiber felt and
hard carbon fiber felt

The present invention relates to a composite material and in particular a high temperature-resistant composite material.

As thermal insulation in high-temperature applications, for example as thermal insulation in high-temperature furnaces, materials based on carbon are often used on account of their high heat stability and their chemical inertness with respect to the substances present in the furnace interior. In order to prevent heat losses through thermal radiation as well as through thermal conduction and convection, composite materials comprising for example a layer of carbon fiber-reinforced carbon and a graphite foil have already been proposed as thermal insulation in high-temperature applications. The layer of carbon fiber-reinforced carbon particularly prevents heat losses due to thermal conduction, whilst the graphite foil has a reflecting effect and therefore prevents heat loss due to thermal radiation.

On account of its outstanding heat-insulating properties, however, thermal insulation based on hard carbon fiber felt is often used in practice. However, hard carbon fiber felt is very brittle, for which reason it can only be machined with difficulty. On account of these properties, when hard felt sheets are being machined to size for example, it may happen that material crumbles away especially at the corners of the sheets, and this can lead to the sheets no longer being able to be used in a precisely fitting manner in the component to be insulated. This problem occurs especially when individual regions of the hard felt insulation are to be replaced in an existing insulation based on hard felt, so that new hard felt material has to be inserted with a precise fit into an existing insulation

from which parts to be replaced have previously been removed. Furthermore, hard carbon fiber felts are comparatively costly on account of their complex production process. Finally, the heat-insulating properties of hard carbon fiber felts also need to be improved.

The problem of the present invention, therefore, is to make available a high temperature-resistant material based on hard carbon fiber felt, which on the one hand has excellent heat-insulating properties and can be produced at comparatively low cost, and which on the other hand can be easily machined, in particular can easily be machined to an exact size.

According to the invention, this problem is solved by a composite material, which comprises at least one layer of soft carbon fiber felt and at least one layer of hard carbon fiber felt, wherein the at least one layer of soft carbon fiber felt is connected to the at least one layer of hard carbon fiber felt via a binder.

The solution is based on the knowledge that, with a composite material wherein at least one layer of hard carbon fiber felt is connected to at least one layer of soft carbon fiber felt via a binder, the positive properties of hard felt not only retained, but even improved in respect of the heat-insulating properties, and at the same time the negative properties of hard felt, such as comparatively great brittleness, low flexibility and high production costs, can be overcome or at least considerably reduced. In particular, such a composite material has a high degree of flexibility and a low degree of brittleness, for which reason it can easily be machined and in particular can easily be machined to an exact size. Apart from this, such a composite material is comparatively inexpensive, because in the latter expensive hard felt is replaced by less costly soft felt. In addition, on account

of the combination of soft felt-hard felt, this composite material has better heat-insulating properties compared to a material of identical dimensions made of hard felt alone. On account of these properties, the composite material according to the invention is outstandingly well suited, amongst other things, for use as thermal insulation in high-temperature furnaces. On account of its easy machineability, the composite material according to the invention is also particularly well suited for use in the repair of existing thermal insulation based on hard felt, wherein for example a part of an existing thermal insulation, which for example is made solely of hard felt, is replaced with a precise fit by the composite material according to the invention.

Within the meaning of the present invention, in conformity with the standard definition in the technical field of relevance here, hard (carbon fiber) felt is understood to denote a felt which, apart from carbon fibers, contains a matrix of binder, whereas soft (carbon fiber) felt is a felt which contains no matrix and no binder. On account of this, soft felt is flexible, whereas hard felt is dimensionally stable.

Furthermore, within the meaning of the present invention, carbon fibers are generally understood, also in conformity with the standard definition in the technical field of relevance here, to mean fibers made from carbon-containing starting materials.

According to the invention, the at least one layer of soft carbon fiber felt is connected to the at least one layer of hard carbon fiber felt via a binder. This is understood to mean that the two layers are connected directly to one another by the effect of a binder, wherein the binder can be constituted as an intermediate layer between the soft felt layer and the hard felt layer or the soft felt layer

and the hard felt layer can be connected to one another by binder present at the boundary faces of the adjacent felt layers, without an intermediate layer of binder having to be formed between the two felt layers. This connection is preferably a large-area connection, i.e. the two felt layers are connected to one another at least substantially over their whole contact area via a binder. The contact area of the two felt layers is preferably constituted in each case by a flat side of the felt layers. Since the two flat sides are never completely or ideally planar, the two flat sides will in reality not make contact over the whole area, but will make contact over a large number of contact regions. In this case, at least substantially all the contact regions are preferably connected to one another via a binder.

As a binder for this purpose, use may be made of all binders which can connect a hard felt layer and a soft felt layer fixedly to one another, wherein use is made particularly preferably of carbon-containing binders and very particularly preferably those selected from the group comprising phenol resins, pitches, furan resins, phenyl esters, epoxy resins and any mixtures of two or more of the aforementioned compounds. According to a highly preferable embodiment of the present invention, a binder selected from the aforementioned group is used that contains two-dimensionally extending particles of natural graphite and/or of expanded graphite, wherein two-dimensionally extending particles are understood here to mean particles which have a greater dimension in the area (diameter) than the thickness. The average diameter of the particles can lie for example between 1 and 250 μm and preferably between 5 and 55 μm . Such binders have a high degree of anisotropy, wherein the thermal conduction is only slight over the interface between the adjacent layers, because the two-dimensionally extending anisotropic particles are orientated parallel to the adjacent material layers. These

binders are then thermally and/or chemically hardened, wherein the chemical hardening can be achieved for example by addition of acid and the thermal hardening can be carried out for example at a temperature of at least 50°C and preferably at 100 to 200°C. After the hardening, carbonisation or graphitisation can optionally be carried out.

In principle, the at least one layer of soft carbon fiber felt can have any layer thickness. Good results are obtained, however, especially with regard to excellent heat-insulating properties and good machineability of the composite material, when the at least one layer of soft carbon fiber felt has a thickness between 1 and 100 mm, preferably between 1 and 50 mm and particularly preferably between 2 mm and 20 mm.

The present invention is likewise not particularly limited with regard to the density and the weight per unit area of the at least one layer of soft carbon fiber felt. With regard to achieving excellent heat-insulating properties and good machineability of the composite material, however, it has proved to be advantageous that the at least one layer of soft carbon fiber felt has a density between 0.01 and 1 g/cm³, preferably between 0.05 and 0.5 g/cm³ and particularly preferably between 0.08 and 0.15 g/cm³.

For the same reasons, it is preferable that the at least one layer of soft carbon fiber felt has a weight per unit area between 50 and 10,000 g/cm², particularly preferably between 100 and 5,000 g/cm² and very particularly preferably between 200 and 1500 g/cm².

As a development of the inventive idea, it is proposed that the carbon fibers of the at least one soft felt layer have a length between 0.1 and 500 mm, preferably between 1 and 250 mm and particularly preferably between 40 and 100 mm.

According to a further preferred embodiment of the present invention, the carbon fibers of the at least one soft felt layer have a fineness between 0.1 and 100 dtex, preferably between 0.5 and 25 dtex and particularly preferably between 1 and 5 dtex.

The soft carbon fiber felt layer can be produced by the fact that fibers comprising suitable starting materials are matted together by felting, before the felt is carbonised or optionally graphitised. The carbonisation is preferably carried out at a temperature of at least 600°C and at most 1500°C, whereas the optional graphitisation is preferably carried out at a temperature between 2000°C and 2500°C. The performance of graphitisation is especially preferred when the composite material produced using the soft felt layer is intended to be particularly stable or inert with respect to chemicals, in particular with respect to molecular oxygen. The carbonisation and graphitisation can also be carried out as the concluding step in the composite material production, i.e. only after the individual layers of the composite material have been arranged one upon the other.

As an alternative to the aforementioned embodiment, the soft carbon fiber felt layer can also be produced by the fact that fibers comprising suitable starting materials are first carbonised or graphitised before the carbon fibers thus obtained are matted together.

In the case of both the aforementioned embodiments, fibers comprising any carbon-containing material can be used as initial fibers, insofar as said material can be carbonised to form carbon or graphitised to form graphite by a heat treatment. Cellulose fibers, polyacrylonitrile fibers (PAN fibers), peroxidised polyacrylonitrile fibers (PANOX fibers) and pitch fibers have proved to be particularly

well suited for this purpose. Use is preferably made of monofilaments comprising one material, for example exclusively polyacrylonitrile fibers. However, it is also possible to use a fiber mixture, such as for example a mixture comprising polyacrylonitrile fibers and cellulose fibers, or bifilaments, i.e. fibers which, in the form of a core-sheath structure, contain both polyacrylonitrile and cellulose.

In the same way as the soft carbon fiber felt layer, the at least one layer of hard carbon fiber felt also preferably has a layer thickness between 1 and 100 mm, preferably between 1 and 50 mm and particularly preferably between 2 mm and 20 mm.

As a development of the inventive idea, it is proposed that the at least one layer of hard carbon fiber felt has a density between 0.02 and 2 g/cm³, particularly preferably between 0.1 and 1.0 g/cm³ and very particularly preferably between 0.15 and 0.3 g/cm³.

According to a further preferred embodiment of the present invention, the weight per unit area of the at least one layer of hard carbon fiber felt amounts to between 200 and 50,000 g/m² and particularly preferably between 3,000 and 10,000 g/m².

The length and the fineness of the carbon fibers contained in the at least one hard felt layer preferably correspond substantially to the values stated above in respect of the soft felt layer. The length of the fibers of the at least one hard felt layer thus preferably amounts to between 0.1 and 500 mm, particularly preferably between 1 and 250 mm and very particularly preferably between 3 and 100 mm, whereas the fineness of the fibers of the at least one hard felt layer preferably amounts to between 0.1 and 100 dtex,

particularly preferably between 0.5 and 25 dtex and very particularly preferably between 1 and 5 dtex.

In principle, the at least one layer of hard carbon fiber felt can contain any suitable carbon-containing binder, insofar as the latter can be carbonised to form carbon or graphitised to form graphite by a heat treatment. Carbon-containing binders have proved to be particularly suitable binders for the hard felt layer when they are selected from the group comprising phenol resins, pitches, furan resins, phenyl esters, epoxy resins and any mixtures of two or more of the aforementioned compounds.

As a further development of the inventive idea, it is proposed that the at least one hard felt layer is composed such that the latter has a bending strength measured according to DIN 29971 between 0.1 and 20 MPa, preferably between 0.2 and 5 MPa and particularly preferably between 0.5 and 1.5 MPa.

To produce the hard carbon fiber felt layer, a soft carbon fiber felt can be impregnated with a suitable binder, in particular with a binder selected from the group comprising phenol resins, pitches, furan resins, phenyl esters, epoxy resins and any mixtures of two or more of the aforementioned compounds, before it is carbonised or graphitised under the conditions stated above in respect of the production of the soft felt layer. As initial fibers, use is also preferably made here of cellulose fibers, polyacrylonitrile fibers, peroxidised polyacrylonitrile fibers, pitch fibers or any mixtures of two or more of the aforementioned fibers.

Alternatively, the at least one layer of hard carbon fiber felt can also be produced by mixing cellulose fibers, polyacrylonitrile fibers, peroxidised polyacrylonitrile

fibers and/or pitch fibers with binder, then pressing the fibers and by carbonisation or graphitisation thereafter.

According to a further alternative, use is made of only one felt mixture, which has been hardened, as the case may be, by for example pressing, vacuum application, treatment in a heating chamber, treatment in a drying chamber, treatment in an autoclave or chemically by the addition of a hardening agent, said felt mixture being able to be carbonised and/or graphitised after the arrangement of the individual layers of the composite material upon one another together with the other layers of the composite material.

The present invention is not limited with regard to the number of hard felt and soft felt layers. For example, the composite material can comprise only one soft felt layer and one hard felt layer or respectively two, three or more soft felt and hard felt layers. The composite material according to the invention can just as well comprise a differing number of soft felt layers and hard felt layers, for example one soft felt layer and two or more hard felt layers or one hard felt layer and two or more soft felt layers. At least one hard felt layer is connected to at least one soft felt layer over a large area via a binder, wherein it is preferable, however, that all adjacent hard and soft felt layers are connected to one another in each case over a large area via a binder.

According to a preferred embodiment of the present invention, the composite material is built up symmetrically in respect of the arrangement of the hard felt layers and soft felt layers.

For example, the composite material can comprise a central layer of hard carbon fiber felt, which is surrounded on both sides by, in each case, a layer of soft carbon fiber

felt, wherein the two layers of soft carbon fiber felt are connected to the layer of hard carbon fiber felt in each case via a binder. A complementary structure, i.e. a composite material with a central layer of soft carbon fiber felt, which is surrounded on both sides by, in each case, a layer of hard carbon fiber felt, is just as suitable, wherein the two layers of hard carbon fiber felt are connected to the layer of soft carbon fiber felt in each case via a binder. The aforementioned composite materials can comprise these arrangements, i.e. comprise no further layers, or can comprise additional layers of another material, for example one or more graphite foils and/or one or more layers of carbon fiber-reinforced carbon.

As a development of the inventive idea, it is proposed that, in the two aforementioned embodiments, the outer layers are surrounded in each case by a further, complementary felt layer. This leads to a structure with a central layer of hard carbon fiber felt, which is surrounded on both sides by, in each case, a layer of soft carbon fiber felt, on which a layer of hard carbon fiber felt is in turn arranged in each case, or to a structure complementary thereto with a central layer of soft carbon fiber felt, which is surrounded on both sides by, in each case, a layer of hard carbon fiber felt, on which a layer of soft carbon fiber felt is in turn arranged in each case.

In order, for example, to increase the impermeability or barrier properties of the composite material with respect to thermal radiation and gases, the composite material can comprise, apart from at least one soft felt layer and at least one hard felt layer, one or more further layers which, for example, comprise carbon fiber-reinforced carbon and/or graphite foil. This (these) further layer(s) is (are) preferably applied on one of the outermost layers of the composite material or on both outermost layers of the

composite material and are connected to the latter via a binder. However, at least one intermediate layer of such a material can also be provided between individual felt layers, if at least one soft felt layer is connected to at least one hard felt layer directly, i.e. without an intermediate layer (apart from binder).

For example, in the case of the aforementioned embodiment, wherein the composite material comprises a central layer of hard carbon fiber felt, which is surrounded on both sides by, in each case, a layer of soft carbon fiber felt, a graphite foil and/or a layer of carbon fiber-reinforced carbon can be arranged on the outside in each case on the two outer layers of soft carbon fiber felt. Analogous thereto, in the case of the embodiment in which the composite material comprises a central layer of soft carbon fiber felt, which is surrounded on both sides by, in each case, a layer of hard carbon fiber felt, a graphite foil and/or a layer of carbon fiber-reinforced carbon can be arranged on the outside in each case on the two outer layers of hard carbon fiber felt.

If at least one graphite foil is provided in the composite material according to the invention, said graphite foil preferably has a layer thickness between 0.1 and 3 mm and particularly preferably between 0.3 and 1 mm. Such a graphite foil has a high reflection capacity and endows the composite material in particular with a good barrier property, and in particular against the passage of gas.

As a development of the inventive idea, it is proposed that the graphite foil is made of natural graphite and/or of expanded graphite.

According to a further preferred embodiment of the present invention, the density of the graphite foil amounts to 0.1 to 1.5 g/cm³. A densely rolled graphite foil is preferably

used, which has a density of approx. 1.0 g/cm^3 . Use can however also be made of less densely rolled graphite foils, such as for example those with a density of approx. 0.3 g/cm^3 .

The at least one layer of carbon fiber-reinforced carbon (CFC) as an optional component of the composite material is composed of a carbon matrix in which carbon fibers are contained. The carbon fibers can be continuous fibers, this being preferable, or can be staple fibers, this being less preferable, said staple fibers for example having a length between 5 and 250 mm, preferably between 10 and 100 mm and particularly preferably between 50 and 100 mm.

According to a further preferred embodiment of the present invention, the carbon fibers of the CFC layer are constituted in the form of a woven fabric. In an alternative embodiment of the present invention, but one that is also preferred, the carbon fibers of the CFC layer are constituted in the form of a non-woven fabric, wherein the individual fibers of the non-woven fabric can be arranged unidirectionally or multi-axially.

The at least one CFC layer preferably has a layer thickness between 0.1 and 1 mm.

Good results with regard to the conductivity are obtained especially when the at least one CFC layer has a density between 0.4 and 3 g/cm^3 , particularly preferably between 0.8 and 2.0 g/cm^3 and very particularly preferably between 1.0 and 1.5 g/cm^3 .

As the starting material for the matrix of the CFC layer, use can be made of carbon-containing materials, in particular those selected from the group comprising phenol resins, pitches, furan resins, phenyl esters, epoxy resins and any mixtures of two or more of the aforementioned

compounds, whereas pitch or particularly preferably polyacrylonitrile or peroxidised polyacrylonitrile is preferably used as the starting material for the carbon fibers. Fiber mixtures of the aforementioned materials or bifilaments of two or more of the aforementioned starting materials can also be used. The matrix can have a weight per unit area of 100 to 1500 g/m².

Such CFC layers can for example be produced by the fact that peroxidised polyacrylonitrile fibers, polyacrylonitrile fibers and/or pitch fibers are carbonised or graphitised, then the carbon fibers thus obtained are processed to form a woven fabric or a non-woven fabric, which is then impregnated with a binder, before the fabric thus obtained is subsequently heat-treated or optionally carbonised and/or graphitised. Carbon-containing compounds can be used as a binder, preference again being given to those which are selected from the group comprising phenol resins, pitches, furan resins, phenyl esters, epoxy resins and any mixtures of two or more of the aforementioned compounds.

On account of their aforementioned advantageous properties, the composite materials according to the invention can be used especially in heat shields, in thermal insulation, in built-in fixtures in furnaces or in other high-temperature applications, for example in foundries. On account of its easy machineability, the composite material according to the invention is also particularly well suited for use in the repair of existing thermal insulation, wherein for example a part of an existing thermal insulation, which for example is made solely of hard felt, is replaced with a precise fit by the composite material according to the invention.

The composite materials according to the invention can be constituted in any form. For example, they can have a two-

dimensionally extending, in particular plate-shaped form, or can have a round cross-section, i.e. be constituted cylindrical or tubular. Apart from the latter, however, they can also be present in any other forms, including geometrically complex shapes.

A further subject-matter of the present invention is a process for the production of a composite material described above, which comprises the following steps:

- a) preparation of at least one layer of soft carbon fiber felt,
- b) preparation of at least one layer of hard carbon fiber felt and
- c) connection of the at least one layer of soft carbon fiber felt to the at least one layer of hard carbon fiber of felt by means of a binder.

In process step b), the at least one layer of hard carbon fiber felt can be produced for example by impregnation of soft carbon fiber felt with a binder and subsequent heat treatment. Alternatively, the at least one layer of hard carbon fiber felt can be produced in process step b) by mixing fibers with a binder, pressing the mixture thus obtained and subsequent heat treatment.

Furthermore, the process according to the invention can comprise, as process step d), the application of at least one graphite foil and/or at least one layer of carbon fiber-reinforced carbon on at least one of the carbon fiber felt layers.

For the application of a layer of carbon fiber-reinforced carbon, (peroxidized) polyacrylonitrile fibers and/or pitch fibers for example can be carbonised or graphitised in

process step d), then the carbon fibers thus obtained are processed to form a woven fabric or non-woven fabric, which is then impregnated with a binder selected from the group comprising phenol resins, pitches, furan resins, phenyl esters, epoxy resins and any mixtures of two or more of the aforementioned compounds, before the fabric thus obtained is optionally carbonised and/or graphitised.

After the arrangement of the individual layers upon one another, the composite material can optionally be hardened, which can take place for example by pressing, by vacuum application, by treatment in a heating chamber, by treatment in a drying chamber, by treatment in an autoclave or chemically by the addition of a hardening agent.

Finally, the composite material can then be carbonised and/or graphitised.

The present invention is described below, merely by way of example, with the aid of advantageous embodiments making reference to the appended drawings. In the figures:

Fig. 1 shows a cross-sectional view of a composite material according to the invention according to a first example of embodiment of the present invention,

Fig. 2 shows a cross-sectional view of a composite material according to the invention according to a second example of embodiment of the present invention,

Fig. 3 shows a cross-sectional view of a composite material according to the invention according to a third example of embodiment of the present invention,

Fig. 4 shows a cross-sectional view of a composite material according to the invention according to a fourth example of embodiment of the present invention,

Fig. 5 shows a cross-sectional view of a composite material according to the invention according to a fifth example of embodiment of the present invention and

Fig. 6 shows a cross-sectional view of a composite material according to the invention according to a sixth example of embodiment of the present invention.

Composite material 10 represented in figure 1 comprises a central layer of hard felt 12, on the opposing sides whereof a layer of soft felt 14, 14' is arranged in each case, wherein individual layers 12, 14, 14' are each connected to one another over a large area via a binder (not represented). The binder can be provided as an intermediate layer between two adjacent felt layers 12, 14 and respectively 12, 14'. Alternatively, the binder can originate from the contact faces of adjacent felt layers 12, 14, 14'.

In the case of composite material 10 represented in figure 2, the individual layers are built up complementary to those of the composite material represented in figure 1, i.e. the latter comprises a central layer of soft felt 14, on the opposing sides whereof a layer of hard felt 12, 12' is arranged in each case, wherein individual layers 14, 12 and respectively 14, 12' are each connected to one another over a large area via a binder (not represented).

The composite material represented in figure 3 differs from that represented in figure 2 by the fact that a further

layer of soft felt 14', 14" is arranged in each case on the outside on the two layers of hard felt 12, 12'.

The composite materials represented in figures 4 to 6 correspond to those shown in figures 1 to 3, except for the fact that there is arranged in each case on their outer felt layers 14, 14' and respectively 12, 12' and respectively 14', 14" a graphite foil 16, 16' or a layer of carbon fiber-reinforced carbon 18, 18', which can be connected to the felt layer lying in each case thereunder by means of a binder. Alternatively, it would also be possible to provide both a graphite foil and a layer of carbon fiber-reinforced carbon on outer felt layers 14, 14' and respectively 12, 12' and respectively 14', 14", wherein the graphite foil is preferably arranged in this case on the outer side of the layer of carbon fiber-reinforced carbon.

As an alternative to the two-dimensionally extending forms shown in figures 1 to 6, the composite materials according to the invention can also have any other forms, such as for example a cylindrical or tubular form.

List of reference numbers

10	composite material
12, 12'	hard felt (layer)
14, 14', 14"	soft felt (layer)
16, 16'	graphite foil
18, 18'	carbon fiber-reinforced carbon

CLAIMS

1. A composite material, which comprises at least one layer of soft carbon fiber felt (14, 14', 14'') and at least one layer of hard carbon fiber felt (12, 12'), wherein the at least one layer of soft carbon fiber felt (14, 14', 14'') is connected to the at least one layer of hard carbon fiber felt (12, 12') via a binder.
2. The composite material according to claim 1, characterised in that the at least one layer of soft carbon fiber felt (14, 14', 14'') has a thickness between 1 and 100 mm, preferably between 1 and 50 mm and particularly preferably between 2 mm and 20 mm.
3. The composite material according to claim 1 or 2, characterised in that the at least one layer of soft carbon fiber felt (14, 14', 14'') has a density between 0.01 and 1 g/cm³, preferably between 0.05 and 0.5 g/cm³ and particularly preferably between 0.08 and 0.15 g/cm³.
4. The composite material according to at least one of the preceding claims, characterised in that the at least one layer of soft carbon fiber felt (14, 14', 14'') has a weight per unit area between 50 and 10,000 g/cm², particularly preferably between 100 and 5,000 g/cm² and very particularly preferably between 200 and 1500 g/cm².
5. The composite material according to at least one of the preceding claims, characterised in that

the carbon fibers of the at least one soft felt layer (14, 14', 14'') have a length between 0.1 and 500 mm, preferably between 1 and 250 mm and particularly preferably between 40 and 100 mm.

6. The composite material according to at least one of the preceding claims, characterised in that the carbon fibers of the at least one soft felt layer (14, 14', 14'') have a fineness between 0.1 and 100 dtex, preferably between 0.5 and 25 dtex and particularly preferably between 1 and 5 dtex.
7. The composite material according to at least one of the preceding claims, characterised in that the at least one layer of soft carbon fiber felt (14, 14', 14'') has been produced by felting and subsequent carbonisation or graphitisation of cellulose fibers, polyacrylonitrile fibers, peroxidised polyacrylonitrile fibers or pitch fibers.
8. The composite material according to at least one of the preceding claims, characterised in that the at least one layer of hard carbon fiber felt (12, 12') has a density between 0.02 and 2 g/cm³, preferably between 0.1 and 1.0 g/cm³ and particularly preferably between 0.15 and 0.3 g/cm³.
9. The composite material according to at least one of the preceding claims, characterised in that the at least one layer of hard carbon fiber felt (12, 12') contains a carbon-containing binder, which is preferably selected from the group comprising phenol resins, pitches, furan resins, phenyl esters, epoxy

resins and any mixtures of two or more of the aforementioned compounds.

10. The composite material according to at least one of the preceding claims,
characterised in that
the binder, via which the at least one layer of soft carbon fiber felt (14, 14', 14'') is connected to the at least one layer of hard carbon fiber felt (12, 12'), is a carbon-containing binder which is selected from the group comprising phenol resins, pitches, furan resins, phenyl esters, epoxy resins and any mixtures of two or more of the aforementioned compounds.
11. The composite material according to at least one of the preceding claims,
characterised in that
the latter comprises a layer of hard carbon fiber felt (12) and two layers of soft carbon fiber felt (14, 14') arranged on opposing sides of the hard carbon fiber felt (12), wherein the two layers of soft carbon fiber felt (14, 14') are connected to the layer of hard carbon fiber felt (12) in each case via a binder.
12. The composite material according to at least one of the preceding claims,
characterised in that
the latter comprises a layer of soft carbon fiber felt (14) and two layers of hard carbon fiber felt (12, 12') arranged on opposing sides of the soft carbon fiber felt layer (14), wherein the two layers of hard carbon fiber felt (12, 12') are connected to the layer of soft carbon fiber felt (14) in each case via a binder.
13. The composite material according to claim 12,

characterised in that

a further layer of soft carbon fiber felt (14', 14'') is arranged in each case on the outside on the two layers of hard carbon fiber felt (12, 12'), wherein the two outer layers of soft carbon fiber felt (14', 14'') are connected to the corresponding hard carbon fiber felt layer (12, 12') in each case via a binder.

14. The composite material according to at least one of the preceding claims, characterised in that the latter further comprises at least one graphite foil (16, 16') and/or at least one layer of carbon fiber-reinforced carbon (18, 18'), which is (are) preferably arranged on one of the or on both of the outermost felt layers (12, 12', 14, 14', 14'') of the composite material (10).
15. The composite material according to claim 14, characterised in that the at least one graphite foil (16, 16') is made of natural graphite and/or of expanded graphite and has a layer thickness of 0.1 to 3 mm and preferably between 0.3 and 1 mm.
16. The composite material according to claim 14, characterised in that the at least one layer of carbon fiber-reinforced carbon (18, 18') contains continuous fibers or contains staple fibers which have a length between 5 and 250 mm, preferably between 10 and 100 mm and particularly preferably between 50 and 100 mm.
17. The composite material according to claim 14 or 16, characterised in that the fibers of the carbon fiber-reinforced carbon (18, 18') are present in the form of a woven fabric or a

non-woven fabric, which is preferably constituted unidirectionally or multi-axially.

18. The composite material according to at least one of preceding claims 14, 16 or 17, characterised in that the at least one layer of carbon fiber-reinforced carbon (18, 18') has a thickness between 0.1 and 1 mm.
19. The composite material according to at least one of preceding claims 14, 16, 17 or 18, characterised in that the at least one layer of carbon fiber-reinforced carbon (18, 18') has a density between 0.4 and 3 g/cm³, preferably between 0.8 and 2.0 g/cm³ and particularly preferably between 1.0 and 1.5 g/cm³.
20. Use of a composite material according to at least one of claims 1 to 19 in heat shields, in thermal insulation, in built-in fixtures in furnaces or in other high-temperature applications.
21. A process for the production of a composite material according to at least one of claims 1 to 19 comprising the following steps:
 - a) preparation of at least one layer of soft carbon fiber felt (14, 14', 14''),
 - b) preparation of at least one layer of hard carbon fiber felt (12, 12') and
 - c) connection of the at least one layer of soft carbon fiber felt (14, 14', 14'') to the at least one layer of hard carbon fiber felt (12, 12') by means of a binder.

22. The process according to claim 21,
characterised in that,
in step b), the at least one layer of hard carbon
fiber felt (12, 12') is produced by impregnation of
soft carbon fiber felt with a binder and subsequent
heat treatment.
23. The process according to claim 21,
characterised in that,
in step b), the at least one layer of hard carbon
fiber felt (12, 12') is produced by mixing fibers with
a binder, pressing the mixture thus obtained and
subsequent heat treatment.
24. The process according to at least one of claims 21 to
23,
characterised in that
the latter further comprises, as step d), the
application of at least one graphite foil (16, 16')
and/or at least one layer of carbon fiber-reinforced
carbon (18, 18') on at least one of the carbon fiber
felt layers (12, 12', 14, 14', 14").
25. The process according to claim 24,
characterised in that,
in step d), peroxidised polyacrylonitrile fibers,
polyacrylonitrile fibers and/or pitch fibers are
carbonised or graphitised, then the carbon fibers thus
obtained are processed to form a woven fabric or non-
woven fabric, which is then impregnated with a binder
selected from the group comprising phenol resins,
pitches, furan resins, phenyl esters, epoxy resins and
any mixtures of two or more of the aforementioned
compounds, before the fabric thus obtained is
carbonised or graphitised.