**Title:** CORE ASSEMBLY FOR A BRAKE DISK

**Abstract:** A core assembly (4) for a brake disc (8) of ceramic material provided with two rotor plates (12) having a predetermined axis (X), the said plates (12) having radially an inner edge (13) and an outer edge (14), having a predetermined thickness (S) and being separated from each other by a central layer (15) with ventilation ducts (16). The core assembly (4) can be inserted into a mould and comprises at least one core (20) provided with a core body (24) designed to produce a ventilation duct (16) which extends between the inner edge (13) and the outer edge (14). The at least one core body (24) comprises at least one protuberance (28) which projects from the said core body (24) and is designed to produce in a plate (12) a cavity (32) which is directed substantially parallel to the predetermined axis (X) of the plate (12).
DESCRIPTION

"Core assembly for a brake disc"

This invention relates to a core assembly for the manufacture of a brake disc provided with two rotor plates separated by ventilation ducts and a process for obtaining a brake disc using the said core assembly.

In particular this invention relates to a core assembly for the manufacture of a braking surface for a brake disc having ventilation ducts and constructed of a ceramic material such as, for example, C/SiC.

The manufacture of ventilation ducts in braking bands as solid bodies using a mould and a core and then subsequently making holes, generally lying in the plane midway through the thickness of the band and comprising the ventilation ducts or channels, is known in the art.

This process gives rise to a number of problems and disadvantages associated with technological difficulties. In particular, making of the holes in the thickness of the braking band is very expensive and difficult because of the hardness of the materials used.

In addition to this, mechanical machining within the thickness of the braking band is difficult to control in comparison with machining the exterior of the braking band. As a consequence, in the course of internal machining it is not possible to rule out the formation of
sharp edges or even cracks, due for example to chipping of the material during machining to remove turnings, which cannot be accepted in the manufacture of a braking band, especially if the braking band is manufactured from a particularly hard and brittle material such as for example a ceramic compound.

The problem in this invention is that of providing a core for the manufacture of braking bands which have characteristics such as to satisfy the abovementioned requirements and at the same time to overcome the disadvantages occurring in the known art. These disadvantages and restrictions are effectively overcome by a core assembly according to Claim 1. Other embodiments of the core assembly are described in the subsequent claims.

Other advantages and characteristics of the present invention will become clear from the following detailed description which is given with reference to the appended drawings which are provided purely by way of non-limiting example and in which:

Figure 1 represents a perspective view of a core assembly according to one embodiment of the invention,

Figure 2 shows a plan view of the core assembly in Figure 1 from above,

Figure 3 illustrates a magnified detail of a core in the
core assembly in Figure 1,

Figure 4 shows a view of the detail in Figure 3 from the side of arrow IV in Figure 3,

Figure 5 shows a perspective view of a semi-finished product obtained by moulding using the core assembly in Figure 1,

Figure 6 shows a plan view of the semi-finished product in Figure 5 from above,

Figure 7 shows a perspective view in partial cross-section of a brake disc obtained using the core assembly in Figure 1,

Figure 8 shows a perspective view of a core assembly according to another embodiment of this invention,

Figure 9 shows a plan view of the core assembly in Figure 8 from above,

Figure 10 shows a plan view of a core assembly according to another embodiment from above, and

Figure 11 shows a plan view of a core assembly according to another embodiment of the invention from above.

Components or parts which are common to the embodiments described below will be indicated using the same numerical references.

With reference to the abovementioned figures, 4 generically indicates a core assembly for a brake disc designed to be inserted into a mould for manufacturing a
brake disc 8 having two rotor plates 12 with a predefined axis X, as illustrated for example in Figure 5, of a predetermined thickness S. The said plates extend radially from an inner edge 13 to an outer edge 14 and are separated from each other by a central layer 15 incorporating ventilation ducts or channels 16. Core assembly 4 comprises at least one core 20 provided with a core body 24 which extends substantially from said inner edge 13 to said outer edge 14 and which is designed to produce a ventilation duct capable of providing a passage for the flow of a fluid through the central layer 15 and therefore between plates 12, the said fluid flowing for example radially between the inner edge and the outer edge.

According to one embodiment, the core assembly comprises a plurality of cores 20 which extend in a preferably substantially radial direction, that is passing through predetermined axis X. Core body 24 advantageously comprises at least one protuberance 28, which projects from said core body 24 along an axis P, which according to one embodiment is substantially parallel to the said axis X. The said at least one protuberance 28 is designed to produce a cavity 32 in a plate 12. Preferably the said cavity 32 is substantially directed parallel to the predefined axis X.
of plate 12. Preferably said cavity 32 is in fluid communication with the ventilation duct.

According to one embodiment, the said at least one protuberance 28 is designed to produce a cavity 32 having a depth which is less than the said predetermined thickness $S$ of plates 12.

According to one embodiment, the said at least one protuberance 28 is designed to produce a cavity 32 having a depth which is equal to at least the said predetermined thickness $S$ of plates 12.

According to another embodiment, said core body 24 has a pair of bases 36 which are substantially flat and perpendicular to predetermined axis $X$ of plates 12, said bases 36 enclosing a thickness of the said core body 24 along a direction substantially parallel to predetermined axis $X$.

Preferably at least one protuberance 28 projects from at least one of said bases 36, and perpendicularly thereto.

According to a preferred embodiment, said protuberances 28 project from both said bases 36, and perpendicularly thereto.

Preferably, said protuberances 28 are distributed in a mirror-image arrangement on said bases 36 in such a way that each protuberance 28 on one of said bases 36 corresponds to an opposite protuberance 28' in opposite
According to another embodiment the said at least one core body 24 comprises a first end 40, designed to form the said outer edge 14 of said plates 12 and a second end 44 designed to form said inner edge 13 of said plates 12, the said second end 44 being opposite to and tapered with respect to first end 40 so as to form a ventilation duct 16 which tapers from outer edge 14 to inner edge 13 of plates 12.

According to another embodiment, the said at least one core body 24 has a transverse cross-section in a plane parallel to the said predetermined axis X which tapers from first end 40 towards second end 44 in such a way as to form connecting walls 48 having a substantially constant transverse cross-section between resulting plates 12.

According to another embodiment, the said at least one core body 24 has a substantially oval shape in transverse cross-section.

According to another embodiment, the said at least one core body 24 has a substantially quadrangular shape in transverse cross-section.

Preferably, said protuberances 28 have a substantially cylindrical shape with a circular base designed to produce cavities in corresponding plates 12.
According to another embodiment, said protuberances 28 have a substantially cylindrical shape with an elliptical base designed to produce cavities in corresponding plates 12.

Said core body 24, as illustrated for example in Figure 1, is substantially straight in a preferential direction R perpendicular to said predetermined axis X and is located parallel to a radial direction of the corresponding plates in such a way as to form a substantially radial ventilation duct 16.

According to another embodiment, illustrated for example in Figure 8, said core body 24 is substantially directed along a preferential direction R perpendicular to said predetermined axis X and incident with respect to a radial direction of the resulting plates in such a way as to form a ventilation duct 16 which is substantially inclined with respect to the said radial direction.

According to another embodiment, illustrated for example in Figure 10, the at least one core body 24 has a substantially curved shape, forming a substantially curved ventilation duct 16 between plates 12.

Advantageously, said at least one core body 24 comprises a core-holder 52 corresponding to said first and second end 40,44 designed to offer support and positioning for core body 24 in a corresponding mould.
Advantageously, core assembly 4 comprises a crown 56 joining the cores, illustrated for example in Figure 11, which connects cores 20 together in such a way as to make cores 20 which constitute core assembly 4 of one piece with each other.

Preferably said joining crown 56 joins cores 20 at said first and second ends 40,44. Preferably core 20 is constructed of a material which melts. In this way the molten material of the core can be discharged from the mould during the process of moulding to manufacture the disc, with spaces forming ventilation channels 16 remaining in its place. Preferably core 20 is constructed of a material which melts in a specific temperature range. Preferably core 20 is made of a material which melts at a temperature below the pyrolysis temperature.

The process for forming the braking band of the brake disc through the use of a forming mould will now be described.

The said mould, which is not illustrated, comprises two plates which under operating conditions are joined together in such a way as to bound a forming cavity. The plates are operated for example by pistons which can move along an axis X-X which coincides with the predetermined axis of plates 12.
Initially, when the mould is in the open configuration, or when the two plates are at a distance from each other, a layer of a mixture in the solid state is deposited in the forming cavity.

Typically said mixture of the layer in the solid state comprises fibres and/or filaments of carbon-based materials selected from the group comprising fibrous materials obtained by the pyrolysis of various products of synthetic origin.

These materials are mixed with a binder such as, for example, a phenolic resin, an acrylic resin, or the like. The binder can be added to the mixture in any desired form, for example in the solid, semi-liquid or liquid state or in solution.

The mixture may also contain other additives conventionally used as fillers and, indirectly, for the purpose of controlling the porosity and density of the desired composite material.

Core assembly 4 is then positioned above the layer in such a way as to cover it and at the same time in such a way as to be held suspended and not sink into the mixture. This suspension is preferably achieved through the core’s core-holder.

After the core has been positioned within the forming cavity another layer of the aforesaid mixture is
deposited on the core in such a way as to produce stratification; at this point the mould can be closed. The braking band is formed through a first heating at a temperature and pressure exerted by the pistons on the layers of mixture such as to cause hardening of the layers so that they take up a three-dimensional structure.

By the term three-dimensional structure, referring to the material which will form the braking band of this invention, it is meant that this material has a conformation such that it will not collapse on itself at the temperature at which the core begins to melt.

Typically the said first heating is effected at a temperature of between 80 and 180°C. The semi-finished product so obtained is then removed from the corresponding mould and placed in a furnace of the conventional type.

In the said furnace the said semi-finished product is subjected to a further heating at a temperature such as to melt the core. Once molten, the material, for example a metal, comprising the core is collected in a melting pot for re-use. This molten material is discharged from the porosities or suitable channels, suitably orientating the semi-finished product.

This second heating is performed at a temperature which
depends substantially on the type of metal forming the core.

For example in the case of a core of tin-based alloy, this second heating temperature preferably lies between 150 and 250°C, even more preferably between 180 and 220°C, while when the core is a zinc-based alloy this second heating temperature preferably lies between 250 and 450, even more preferably between 300 and 400°C.

The said second heating results in a semi-finished product comprising ventilation channels corresponding to the empty space left when molten core assembly 4 flows out. In particular, after the second heating the semi-finished product comprises both radial and axial ventilation channels as a result of the use of a core body having a substantially radial extent and protuberances which project axially.

At the end of the second heating the semi-finished product may be treated in accordance with the known art for the manufacture of braking bands.

Typical examples of the said treatments are pyrolysis and silicification. Preferably these are carried out as described in the Applicant's European Patent Application No. 00830093.1 which is included here for reference as regards the aforesaid pyrolysis and silicification treatments, in which the pyrolysis takes place at a
temperature of between 900 and 1200°C in the presence of a flow of inert gas such as nitrogen and argon and with an excess pressure of 10-100 mbar and silicification is carried out at a temperature of 1400-1700°C under vacuum reducing the pressure from 900 mbar to 300 mbar.

In addition to this, if necessary, the braking band according to the invention so obtained may be subjected to finishing operations, for example surface finishing, which may be carried out dry or wet in a conventional manner using a grinding operation.

In addition to this, it is known that in some cases braking bands manufactured from the materials described above can give rise to possible cracks or fractures following thermal and/or compression stresses to which a braking band is subjected when in use. Said cracks or fractures tend to propagate rapidly throughout the structure of a braking band and may cause its complete disintegration.

Advantageously, it is possible to introduce a plurality of reinforcing fibres so as to prevent the propagation of cracks into the mixture for forming the braking band described above.

Examples of the said reinforcing fibres and their incorporation in the mixture which will form the braking band are described in the Applicant’s European Patent
Application No. 00830093.1 which is included here for reference as regards the aforesaid reinforcing fibres and their incorporation.

In addition to this, braking band 8 has an outer edge with openings corresponding to the ventilation ducts described above and an inner edge provided with seats for housing corresponding teeth of a brake disc hub (not shown).

As may be seen from what has been described, the core assembly according to the invention makes it possible to overcome the disadvantages presented by moulds of the known art.

In fact, the core assembly disclosed makes it possible to produce braking bands with radial and axial ventilation ducts rapidly and economically.

The axial ventilation ducts are formed from the cavities generated by the protuberances and are in fluid communication with the radial ducts.

The axial ducts are not therefore obtained by drilling operations and therefore there is no risk of creating unacceptable cracks in the plates.

The presence of a core-holder provides appropriate support for the core assembly and at the same time an optimum balancing of the pressures exerted on the mould during the stage of forming the braking band.
This invention also relates to a simple and economic process which makes it possible to obtain a braking band with the necessary safety characteristics from the structural point of view which is easy to manufacture.

In addition to this the advantages of the process for producing the braking band according to this invention will be immediately apparent from what has been said above.

One advantage is that the core, from which the ventilation channels in the braking band according to this invention are obtained, is made of a material which is able to begin to melt at a temperature at which the material which will form the braking band has already adopted a three-dimensional structure. This makes it possible to form the ventilation ducts without causing collapse of the braking band which is being formed on the core.

Naturally, the principle of the invention remaining the same, the forms of embodiment and details of construction may be varied widely with respect to those described and illustrated, which have been given purely by way of example, without thereby departing from the scope of the invention.
CLAIMS

1. A core assembly (4) for a disc (8) of ceramic material provided with two rotor plates (12) having a predetermined axis (X), the said plates (12) having radially an inner edge (13) and an outer edge (14), having a predetermined thickness (S) and being separated from each other by a central layer (15) with ventilation ducts (16), the said core assembly (4) being designed to be inserted in a mould and comprising:

at least one core (20), fitted with a core body (24), designed to produce a ventilation duct (16) extending between the said inner edge (13) and the said outer edge (14), in which

the at least one core body (24) comprises at least one protuberance (28) which projects from the said core body (24) and is designed to produce within a plate (12) a cavity (32) which is directly substantially parallel to the predetermined axis (X) of the plate (12).

2. A core assembly (4) according to Claim 1, in which

the said cavity (32) is in fluid communication with the said ventilation duct (16).

3. A core assembly (4) according to Claim 1 or 2, in which the said at least one protuberance (28) is designed to produce a cavity (32) having a depth less than the said predetermined thickness (S) of the plates (12).
4. A core assembly (4) according to Claim 1 or 2, in which the said at least one protuberance (28) is designed to produce a cavity (32) having a depth at least equal to the said predetermined thickness (S) of the plates (12).

5. A core assembly (4) according to any one of the preceding claims, in which the said core body (24) comprises a pair of bases (36) which are substantially flat and perpendicular to the said predetermined axis (X) of the plates (12), the said bases (36) enclosing a thickness of the said core body along a direction which is substantially parallel to the predetermined axis (X).

6. A core assembly (4) according to Claim 5, in which at least one protuberance (28) projects from at least one of the said bases (36), and perpendicularly thereto.

7. A core assembly (4) according to Claim 5 or 6, in which the said protuberances (28) project from both the said bases (36), and perpendicularly thereto.

8. A core assembly according to Claim 7, in which the said protuberances (28) are distributed in mirror-image form on the said bases (36) in such a way that an opposite protuberance (28’) on the opposite base (36’) corresponds to each protuberance (28) on one of the said bases (36).

9. A core assembly (4) according to any one of the
preceding claims, in which the said at least one core body (24) comprises a first end (40) designed to form the said outer edge (14) of the said plates (12) and a second end (44) designed to form the said inner edge (13) of the said plates (12), the said second end (44) being opposite to and tapered with respect to the first end (40) in such a way as to form a ventilation duct (16) which tapers from the inner edge (13) to the outer edge (14) of the plates (12).

10. A core assembly (4) according to Claim 9, in which the said at least one core body (24) has a transverse cross-section in a plane parallel to the said predetermined axis (X) which tapers from the first end (40) to the second end (44) in such a way as to form connecting walls (48) having a substantially constant transverse cross-section between the resulting plates (12).

11. A core assembly (4) according to any one of the preceding claims, in which the said at least one core body (24) has a substantially oval shape in transverse cross-section.

12. A core assembly (4) in accordance with any one of claims from 1 to 10, in which the said at least one core body (24) has a substantially quadrangular shape in transverse cross-section.
13. A core assembly (4) in accordance with any one of the preceding claims, in which the said protuberances (28) have a substantially cylindrical shape designed to produce cavities in the corresponding plates (12).

14. A core assembly (4) according to any one of the preceding claims, in which the said core body (24) is substantially directed along a preferential direction (R) perpendicular to the said predetermined axis (X) and located parallel to a radial direction of the resulting plates (12) in such a way as to form a substantially radial ventilation duct (16).

15. A core assembly (4) according to any one of Claims from 1 to 13, in which the said core body (24) is substantially directed along a preferential direction (R) perpendicular to the said predetermined axis (X) and incident with respect to a radial direction of the resulting plates (12) in such a way as to form a ventilation duct (16) which is substantially inclined with respect to the said radial direction.

16. A core assembly (4) according to any one of claims from 1 to 13, in which the at least one core body (24) has a substantially curved shape forming a substantially curved ventilation duct (16) between the plates (12).

17. A core assembly (4) according to any one of the preceding claims, in which the said at least one core
body (24) comprises a core-holder (52) designed to provide a support and positioning for the core body (24) in a corresponding mould at the said first and second end (40, 44).

18. A core assembly (4) according to any one of the preceding claims, comprising a crown (56) joining the cores (20) which joins the cores (20) together in such a way as to make the cores (20) forming the core assembly (4) of one piece with each other.

19. A core assembly (4) according to Claim 18, in which the said joining crown (56) joins the cores (20) at the said first and second ends (40, 44).

20. A brake disc (8) comprising a braking band obtained by a process which uses a core as described in one of claims from 1 to 19.

21. A brake disc (8) of composite material, provided with two rotor plates (12) having a predetermined axis (X), obtained by a process comprising the stages of:

a) forming a core (20) having a core body (24) designed to form a ventilation duct (16) extending between an inner edge (13) and an outer edge (14) of the said disc, and comprising at least one protuberance (28) which projects from the said core body (24) substantially parallel to the said predetermined axis (X),
b) inserting the said core in a mould,
c) filling the said mould with at least two layers of material which will form the braking band in such a way that the said core is sandwiched between the said at least two layers.

22. A brake disc (8) of composite material obtained through the process in Claim 21, the said process also comprising the stages of:
heating the said mould to a temperature such as to cause hardening of the said at least two layers so that the said at least two layers adopt a three-dimensional structure.

23. A brake disc (8) of composite material obtained through the process in Claims 21 or 22, the said process also comprising the stage of:
heating the said mould to a temperature such as to cause melting of the material of the said core.

24. A brake disc (8) of composite material obtained through the process in claims from 21 to 23, the said process also comprising the stage of pyrolysis.

25. A brake disc (8) of composite material obtained through the process in claims from 21 to 24, the said process also comprising the stage of silicification.

26. A brake disc (8) of composite material obtained through the process in claims from 21 to 25, the said
process also comprising the stage of surface finishing of the said disc.

27. A brake disc (8) of composite material obtained through the process in claims from 21 to 26, in which the said core (20) is of a material which will melt.

28. A brake disc (8) of composite material obtained through the process in claims from 21 to 26, in which the said core is of a metal material.

29. A brake disc (8) of composite material obtained through the process in claims from 21 to 26, in which the said core (20) is of a metal material which melts at a temperature below the pyrolysis temperature.

30. A brake disc (8) of composite material obtained through the process in claims from 21 to 26, in which the said core is a metal alloy capable of melting at a temperature of between 150 and 450°C.
**INTERNATIONAL SEARCH REPORT**

**A. CLASSIFICATION OF SUBJECT MATTER**

| IPC    | F16D65/12 |

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

**B. FIELDS SEARCHED**

Maximum documentation searched (classification system followed by classification symbols)

| IPC    | F16D B22D |

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 (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

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Further documents are listed in the continuation of box C. Patent family members are listed in annex.

**Date of the actual completion of the International search**

4 February 2004

**Date of mailing of the international search report**

11/02/2004

Name and mailing address of the ISA

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Topolski, J
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