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(54) **PROCEDE DE PRODUCTION DE DISQUES DE FREINS COMPOSES D'ELEMENTS CERAMIQUE ET DOTES D'UN MOYEU METALLIQUE**

(54) **METHOD FOR PRODUCING BRAKE DISKS CONSISTING OF CERAMIC PARTS WITH METAL HUBS**

(57) The invention relates to a method for producing brake disks with friction surfaces consisting of ceramic materials, especially composite materials. At least one ceramic part is placed in a diecasting mould and is joined to molten metals by casting under pressure, in order to obtain a rotationally symmetrical body. Said body contains at least one ceramic (composite) segment that is symmetrical to the axis of rotation of the metal body and projects beyond at least one surface of the metal body that is perpendicular to said axis.

Abstract:

Method for producing of brake discs consisting of ceramic parts with metal hubs

Method for the production of brake discs having friction areas made of ceramic materials, in particular composite materials, wherein at least one ceramic portion is placed in a diecasting mould and is joined with molten metals by casting under pressure to a rotationally symmetrical body which contains at least one ceramic (composite) segment which is arranged symmetrically with respect to the axis of rotation of the metal body and juts out over at least one surface of the metal body which is perpendicular to the axis.

Method for producing brake discs consisting of ceramic parts with metal hubs

Today, the following requirements are made on heavy-duty brakes: they must convert large (kinetic) energies into thermal energy in a short time, even immediately after a braking (that ist mostly in the hot stage) they must not lose efficiency substantially, the frictional connection with the vehicle axle must withstand the large torques during deceleration.

At the same time, there is the requirement to make the brake unit as light as possible in order to keep the moment of inertia of the driving axle respectively decelerating axle as small as possible. It is also aspired to select the material pairing for brake discs and brake blocks in such a way that the brake blocks, which are easier to replace, possess the bigger wear within the pairing.

Most heavy-duty brakes are today realized in the type of disc brakes, the brake disc consisting mostly of steel or cast iron. In brakes in which operating temperatures of approximately 250 to approximately 600°C occur (for example Formula I racing cars or aircrafts) brake discs made of carbon fiber reinforced carbon have already been used successfully. This material, however, is oxidised at the surface at superior temperatures and therefore possesses unfavourable properties with long-term use. As is well known, a ceramic composite material having a silicon carbide matrix reinforced with a netting of carbon fibres behaves more favouraby (WO97/22815). Thereby the great dimensional stability and stiffness of the carbon fibres is combined with the favourable wear properties of silicon carbide, in particular, also with its excellent oxidation stability and thermal characteristics. This application describes, that segments of this ceramic composite material are ground to the required shape and then fixed on a steel support between hub and spokes.

The machining of ceramics, in particular ceramic composite materials, is expensive and can be automated only hardly for the large scale manufacture.

The object was therefore to provide a method which makes possible a series production of brake discs, which possess ceramic portions, in particular ceramic composite materials, as friction areas.

This object is achieved by a method for the production of brake discs having friction areas made of ceramic materials, in particular composite materials, wherein at least one ceramic portion is placed in a diecasting mould and is joined with molten metals by casting under pressure to a rotationally-symmetrical body, which contains at least one ceramic (composite) segment which is arranged symmetrically with respect to the axis of rotation of the metal body and juts out over at least one surface of the metal body which is perpendicular to the axis.

Thereby, the location of the ceramic elements in the mould is to be selected in such a way that the axis (of symmetry) of the mould and a zone around this axis with a radius which preferably amounts to at least 1/10 and at most 2/3 of the radius of the finished brake disc, is vacant of ceramic portions. Essential for the dimensioning of this zone around the axis is that the torque caused by the braking deceleration can be conveyed to the axis of rotation.

Preferably, the central portion (close to the axis of symmetry), the hub, is realized in the shape of a pot.

The ceramic portions can have any cross-section, the number of them amounts to at least one, preferably 2 to 80, in particular 4 to 40. The portions must be arranged symmetrically with respect to the axis of rotation, at which portions of different size or different shape can be used likewise at the same time, as long as each portion together with at least one other portion fullfills the symmetry condition respectively is itself rotationally symmetrical. However, it is preferred that all ceramic portions are of the same size. The cross-sections of the ceramic portions can be circular, elliptical or wedge-shaped; however rectangular or trapezoidal cross-sections can also be used.

In principle, all ceramic materials, which are known, can be used as ceramic materials; because of the temperature load however, those materials, which are not degraded by oxidation at the high temperatures which occur during the braking, and which still have an adequate hardness even at these temperatures, are preferred. Such materials are, in particular, fibre-reinforced ceramics, preferably ceramics which are reinforced with carbon fibres or metal whiskers. Silicon carbide and other non-oxidic ceramics, such as silicon nitride, are particularly preferred because of the favourable thermal characteristics, their great hardness and because of their chemical resistance. The various silicon carbide ceramics, such as RSiC (recrystallised silicon carbide), SSiC (sintered SiC) and SiSiC (silicon-infiltrated silicon carbide) are outstandingly suitable, in particular carbon-fibre-reinforced SiC (C/SiC).

The metal which is used as the support and force-transmitting portion must melt at a temperature which is below the decomposition temperature of the ceramic, it must have even at an elevated temperature a sufficient stiffness in torsion to lead the required force into the brake disc, its thermal expansion should not differ too much from that of the ceramic, and it must not (chemically) attack the ceramic. In combination with a ceramic of carbon-fibre-reinforced silicon-infiltrated silicon carbide, for example, aluminium is suitable, just as aluminium alloys with mass portions of at least 40% aluminium in the alloy.

The production of the brake discs takes place in such a way that ceramic segments are put in place symmetrically into a diecasting mould with the aid of suitable automatic placement devices. The molten metal is then injected into this mould at a pressure of approximately 5 to approximately 500 bar. It is advantageous to preheat thereby the diecasting mould. After solidification of the metal, the mould is opened as usual, the part is taken out and the mould is loaded once again with the ceramic inserts, after which the injection procedure can be carried out once again. The cooled-down part can then be remachined in so far as this is necessary.

If only one ceramic portion is used, it is rotationally symmetrical, preferably annular.Preferably, the annulus has individual elements at the side close to the axis, preferably at least two such elements, which elements are juts or recesses towards the axis of rotation. The frictional connection between ceramic and metal is improved because of these elements. In the context of the invention, it is also possible to couple two or more such ring discs at the above-described diecasting method by a metal portion close to the axis. In the case of this embodiment, it has proven favourable to mould between the two discs, in addition to the pot-shaped hub already described, such metal elements which generate, in the sense of a propeller or impeller, an air current between the two discs, which carries away the heat due to energy losses, that arises during braking, more quickly.

The invention is illustrated by the following examples:

Example 1

36 wedge-shaped C/SiC segments (l = approximately 65 mm, w = approximately 18/approximately 10.6 mm, h = 32 mm) were placed by hand into a diecasting mould. Geometrically matching recesses with a depth of 10 mm were provided for these segments in the diecasting mould in such a way that the individual segments form a segmented circle with an external diameter of 320 mm

and an internal diameter of 190 mm. There was a 10 mm wide gap between the individual segments. In the subsequent diecasting process, these gaps were filled with an aluminium alloy (Al-Si12Fe), which leads to the fixing of the individual segments into a 12 mm thick Al support structure and thus to the formation of the friction ring with simultaneous joining of this friction ring with a pot of this Al alloy likewise formed during the diecasting process. The casting mould was heated to 300°C in order to carry out the diecasting.Subsequently, the Al alloy, which was preheated to a temperature of 680°C, was injected into the casting mould under a pressure of approximately 50 bar. The friction unit was removed from the mould after the solidification of the melt and, after cooling-down to room temperature, machined, that is, the friction surface was ground.

Example 2

A C/SiC ring segment with an external diameter of 320 mm and and internal diameter of 190 mm was conveyed by hand into a diecasting mould. There were 10 mm long teeth on the ring inside of this ring shape. The joining on of the pot in the subsequent diecasting takes place by way of these teeth. These teeth were thereby enclosed with the melt of the alloy.

The casting mould was heated to 300°C in order to carry out the diecasting. Subsequently, the Al alloy, which was preheated to a temperature of approximately 680°C, was injected into the casting mould under a pressure of approximately 50 bar. The friction unit was removed from the mould after the solidification of the melt and, after cooling-down to room temperature, machined, that is, ground at the surface.

Claims

1. Method for the production of brake discs having friction areas made of ceramic materials, in particular composite materials, wherein at least one ceramic portion is placed in a diecasting mould and is joined with molten metals by casting under pressure to a rotationally symmetrical body which contains at least one ceramic (composite) segment which is arranged symmetrically with respect to the axis of rotation of the metal body and juts out over at least one surface of the metal body which is perpendicular to the axis.

2. Method according to claim 1, characterised in that a ring disc made of ceramic is put in place.

3. Method according to claim 1, characterised in that at least two ceramic portions are put in place, which are arranged as parallel ring discs.

4. Method according to one of claims 2 or 3, characterised in that the ring discs have juts towards the axis or recesses aligned away from the axis, which improve the frictional connection between metal and ceramic.

5. Method according to claim 1, characterised in that the portion of the metal, that is close to the axis, is realized as a pot-shaped hub.

6. Method according to claim 3, characterised in that metal portions are arranged between the two discs which have the effect of a propeller or an impeller and cause an air current between the two discs, which cools the

discs in the sense of an internal ventilation.

7. Brake disc which can be produced according to the method according to claim 1.

8. Brake disc which can be produced according to the method of claim 2.

9. Brake disc which can be produced according to the method of claim 3.

10. Brake disc which can be produced according to the method of claim 6, wherein the metal portions arranged between the two discs cause the effect of a propeller or an impeller, which causes an air current between the two discs, which cools the discs in the sense of an internal ventilation.

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