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(71) Applicant and

(72) Inventor: **LEE, Kwang Rae** [KR/KR]; Pander Apartment
1-602, 258, Guwol-1dong, Namdong-gu, Incheon 405-221
(KR).

(74) Agent: **LEE, Dae Sun**; Chongkundang Bldg., 5F, 441,
Shipjeong-2dong, Bupyeong-gu, Incheon 403-132 (KR).

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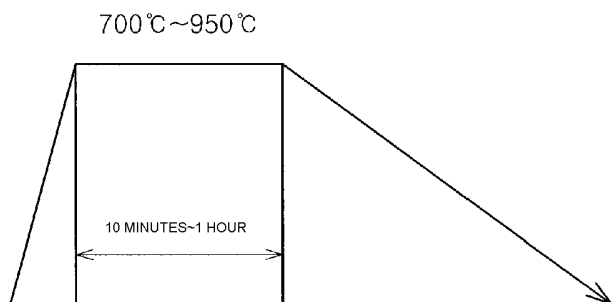
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(54) Title: METHOD FOR MANUFACTURING A BRAKE DISK FOR VEHICLES



(57) Abstract: The present invention relates to a method for manufacturing brake disks for vehicles, whereby the fuel expense economy is improved through the decrease in the weight of vehicle, the vehicle's life is extended through the increase in wear resistance and the environmental pollution is prevented.

Description

METHOD FOR MANUFACTURING A BRAKE DISK FOR VEHICLES

Technical Field

[1] FIELD OF THE INVENTION

[2] The present invention relates to the method for manufacturing a brake disk for vehicles, and more particularly to a method for manufacturing brake disks for vehicles, whereby the fuel expense economy is improved through the decrease in the weight of vehicle, the vehicle's life is extended through the increase in wear resistance and the environmental pollution is prevented.

[3]

[4] BACKGROUND OF THE INVENTION

[5] Generally the brake disk for vehicle, which is a braking means for decelerating and stopping a vehicle through the friction with a brake pad, is manufactured based on ordinary cast iron system including Fe, C, Si, Mn, P and S. However, defects can result during heat treatments due to severe segregations and ununiform composition, so that the heat treatment is generally avoided and the chrome is added before use, instead of heat treatment, in order to improve the resistance to heat and wear.

[6] Incidentally, such an ordinary grey cast iron has the advantage of low production cost due to the easy manufacturing process and the exemption of heat treatment but likewise has the problem of incapability to make the product light-weighted because the thickness of the product can not but be large in order to compensate for the weakened physical property including low toughness and low impact strength. Further, the above-described grey cast iron has the limit in extending the life of product due to the increased wear during use, because the heat treatment is ordinarily not conducted and the additive like chrome is used to increase the hardness in the production steps.

[7] Furthermore, the chrome component, which is added to the material to increase the heat and wear resistances of brake disks made of grey cast iron and which is plated on the surface of disks to enhance the aesthetic effect of the products, is also associated with the environmental pollution because the Cr component can emit to the atmosphere during the course of friction with brake pads at the time of braking.

[8]

[9] SUMMARY OF THE INVENTION

[10] The present invention was created to resolve the above-described problems. Thus, the object of the invention is to provide a method for manufacturing brake disks for vehicles, wherein spherical graphite cast iron is used following heat treatment in manu-

facturing brake disks for vehicles so as to realize the light-weight of products to thereby improve the fuel economy for vehicles, the life of products is prolonged due to the increased wear resistance and the environmental pollution is also prevented because the predetermined resistance to heat and wear is provided despite the absence of the chrome.

[11] The above-described object is achieved according to a preferred aspect of the invention by a method for manufacturing brake disks for vehicles, which comprises the steps of: heating spherical graphite cast iron in the form of a brake disk for vehicle in a non-oxidizing atmosphere so that the core of the cast iron material reaches 850~950°C, said spherical graphite cast iron including 3.0 ~ 3.8 wt.% of C, 2.0 ~ 2.8 wt.% of Si, 0.1 ~ 0.4 wt.% of Mn, 0.01 ~ 0.08 wt.% of P, 0.001 ~ 0.02 wt.% of S and 0.01 ~ 0.05 wt.% of Mg and optionally including either all or two out of the three components of 0.15 ~ 0.4 wt.% of Mo, 0.5 ~ 1.2 wt.% of Cu and 0.6 ~ 2.0 wt.% of Ni, and the balance of Fe as well as inevitable impurity, said spherical graphite cast iron consisting of 2 ~ 40 % of ferrite structure and 60 ~ 98 % of pearlite structure, said spherical graphite cast iron having over 70 % of spherizing rate, said spherical graphite cast iron having the number of graphites at over 100/mm²; after maintaining for 10 min. ~ 2 hr. after said temperature of 850~950°C is reached, maintaining for 1 ~ 2 hr. in a low-temperature salt bath furnace or oil furnace maintained at 300 ~ 420 °C and stirred; and subjecting the brake disk of graphite cast iron so treated to air-cooling or water-cooling.

[12] According to another aspect of the invention, there is provided the method for manufacturing brake disks for vehicles, wherein prior to the above-described heat treatment, the core of the above-described material is heated to 700 ~ 950 °C and maintained at the same temperature for 10 min. ~ 1 hr. followed by air-cooling or furnace-cooling.

[13] According to still other aspect of the invention, there is provided the method for manufacturing brake disks for vehicles, wherein after the above-described heat treatment, the above-described material is machined to form surface of contact with brake pads, surface for mounting on wheel and holes for receiving bolts, heated so that the core of material reaches 300 ~ 600°C and maintained at the same temperature for 10 min. ~ 1 hr. and thereafter the material is air-cooled or water-cooled.

[14]

[15] BRIEF DESCRIPTION OF THE DRAWINGS

[16] Fig. 1 shows the perspective view of a brake disk for vehicle according to the invention.

[17] Fig. 2 shows the diagram illustrating the austempering heat-treating cycle according to a preferred embodiment of the invention

[18] Fig. 3 shows the diagram illustrating the heat-treating cycle for the material before the austempering heat-treating of the above-described embodiment

[19] Fig. 4 shows the diagram illustrating the heat-treating cycle for the machined workpiece after the austempering heat-treating of the above-described embodiment.

[20]

[21] DETAILED DESCRIPTION OF THE INVENTION

[22] A preferred embodiment of the invention is described in detail below by referring to the accompanying drawings.

[23] Fig. 1 shows the perspective view of a brake disk for vehicle according to the invention, Fig. 2 shows the diagram illustrating the austempering heat-treating cycle according to a preferred embodiment of the invention, Fig. 3 shows the diagram illustrating the heat-treating cycle for the material before the austempering heat-treating of the above-described embodiment, and Fig. 4 shows the diagram illustrating the heat-treating cycle for the machined workpiece after the austempering heat-treating of the above-described embodiment.

[24] Referring to these figures, the present invention includes roughly a manufacturing process in which the mass of scrap iron and recovered iron mixed with carbon additive is charged into a low-frequency induction furnace, heated to be molten bath, this molten bath is discharged to a container, Fe-Si-Mg are inoculated in the container for a spherizing treatment, and the treated molten iron mass is injected to a sand mold having the shape of a brake disk and left to be cooled, resulting in spherical graphite cast iron; then, an austempering heat-treatment for providing the disk-formed spherical graphite cast iron with mechanical properties such as the heat resistance, wear resistance, elongation and impact strength; optionally an annealing heat-treatment as a pre-treatment before the austempering treatment to relieve the internal stress in cast structures; a machining operation for giving the brake disk the finished shape; and finally an after-treatment for removing the stress generated during the machining.

[25] C should preferably range from 3.0 to 3.8 wt.%. When C is below 3.0 Wt.%, the chance of segregating in the course of the graphite aggregating to balls is high. On the other hand, when 3.8 wt.% is exceeded, the elongation of the material tends to decrease after the heat treatment. Mn at the content of 0.1 ~ 0.4 wt.% acts to promote bainitization during the heat treatment. When the content of Mn is below 0.1 wt.%, the bainitization is decreased during heat treatment, whereas the elongation and impact resistance are decreased due to brittleness, because the local hardening is caused and the uniform structure is not formed because of the segregation, when the content exceeds 0.4 wt.%. Although S is desirably contained at 0.001 ~ 0.02 wt.%, the added quantity of Mn gets decreased as the quantity of S increases.

[26] Mg is usually contained at 0.01 ~ 0.05 wt.% and should be used at over 0.01 wt.%

at least in order to spherize the graphite, but makes the material brittle and unable to obtain the predetermined elongation rate, when 0.05 wt.% is exceeded. Mo contained at 0.15 ~ 0.4 wt.% acts to regulate the cooling speed during the heat-treatment, that is, to cause the formation of uniform structures up to the core of the product with large thickness difference and further acts to suppress the structure variance due to the cooling speed in the course of generating the bainite so as to achieve a uniform structure. When the content of Mo is below 0.15 wt.%, structure becomes ununiform during the cooling. If the content of Mo exceeds 0.4 wt.%, however, segregation tends to be caused and a long retaining hours at a high temperature are required for graphitization.

[27] Cu and Ni have respectively the same effect as Mo and so act to uniformly distribute the spherized grains of graphite and improve the tensile property, and particularly increase the share of pearlites to thereby improve the impact strength via heat treating step. However, when Cu and Ni are below 0.5 wt.% and 0.6 wt.% respectively, the effect of heat treatment vanishes. On the other hand, when the added quantity is more than required, only manufacturing cost would rise, and therefore Cu and Ni should be kept below 1.2 wt.% and 2.0 wt.% respectively. Although all of Cu, Ni and Mo may be added together, only two components can be added for the reason of reducing the casting cost. The contents given for Si and P are those as applied for ordinary cast iron alloys.

[28] Now, regarding the reason for the above-described prescription for the metal structures of spherical graphite cast iron, the ferrite structure and the pearlite structure are distinctively formed depending on the cooling speed of spherized graphite cast iron, wherein less than 60% of pearlite structures would lead to an ununiform structure of the product after the heat treatment, decreasing the effect of the latter so as to cause the irregularity of tensile strength and elongation property, and more than 98% of pearlite structures, on the other hand, would impair the increase of elongation after the heat treatment, obstructing the procurement of product with desired properties.

[29] In addition, the spherization rate and the number of graphites are determined in accordance with the added amount of inoculants and the number of inoculations for spherization in the state of cast iron ware, wherein in the case of less than 70% of spherization rate, partial segregation is generated after the heat treatment to cause an ununiformity of hardness, so that a long time of graphitization at a high temperature is required, which undesirably increases the heat treating cost. Further, the elongation after the heat treatment is improved as the number of graphites within structures is increased, wherein the elongation and the impact strength are abruptly dropped after the heat treatment, if the number is less than 100/mm².

[30] The compositions and the hardness before heat treatment for spherical graphite cast

iron products having the composition and metal structures as described in the above according to the invention and for a conventional grey cast iron product are given in Table 1 for comparison. It is found from the table that the spherical graphite cast iron products according to the invention, in contrast to the conventional grey cast iron product, include Mg used as the inoculant for spherization but does not include Cr, a known hardness improving additive, in respect of the composition, and have relatively higher hardness even in the state before heat treating in respect of the hardness and besides the inventive cast iron products are excellent in the strength, wear resistance, heat resistance, oxidation resistance etc., but on the other hand, the inventive cast iron products are poor in castability and so not applicable to the products with unusually complicated shapes and are so sensitive to the thickness as to cause generation of chills on thinner areas, requiring a heat treating operation to follow after the casting.

[31] Table 1

Comparison of chemical composition(wt.%) and hardness(HB)

Comp. (wt%)	C	Si	Mn	P	Mg	S	Ni	Cu	Mo	Cr	Hardness(HB)
Conventional	3.38	2.48	0.65	0.072	-	0.027	0.09	0.53	-	0.75	170 ~ 200
Inv. Product 1	3.52	2.35	0.3	0.017	0.03	0.016	0.9	0.68	0.15	-	220 ~ 290
Inv. Product 2	3.54	2.4	0.26	0.035	0.02	0.018	1.25	0.65	-	-	220 ~ 290
Inv. Product 3	3.5	2.38	0.22	0.037	0.03	0.015	-	0.68	0.23	-	220 ~ 290
Inv. Product 4	3.58	2.25	0.25	0.02	0.03	0.017	0.96	-	0.22	-	220 ~ 290

[32]

[33] Example 1: Austempering Heat-Treatment

[34] The spherical graphite cast iron products as given above were subjected to austempering heat-treatment with varying temperature condition. The austempering heat-treatment refers to the heat treatment wherein after austenizing treatment for transforming to the austenizing structure the mixed structure of pearlite and ferrite representing the structure of material for casting after heating the latter, tempering treatment is conducted, in which the treated austenite structure is cooled and

maintained in an oil furnace maintained at a predetermined temperature to be transformed to bainite structure. Incidentally, the most important element in the above-described austempering heat-treatment is the tempering temperature at which the austenite structure is transformed to the bainite structure on the ground that the bainite structure exhibits the excellence in all physical properties including the strength, hardness, elongation, impact value, and wear resistance.

[35] Accordingly, a number of spherical graphite cast iron products as listed in Table 1 were caused to be heated to the same austenizing temperature but then subjected to different tempering temperatures to get the result as shown in the following Table 2. Thus, it was found, as appreciable from the Table, that the product with the most ideal mechanical properties fulfilling all the designated physical property values is the one tempering-treated at 300 ~ 420 °C.

[36] Thus, the products fulfilling the predetermined physical properties was produced, by heating spherical graphite cast iron products in an oxygen-free furnace until the core of the material reaches 850 ~ 950°C and maintaining for 10 min. ~ 2 hr. after the foregoing temperature is reached to complete the austenizing treatment, then maintaining the cast iron articles in a low-temperature salt bath furnace or oil furnace maintained at 300 ~ 420°C and kept in agitation for 1 ~ 2 hr. in order to conduct the tempering treatment, and finally causing the cast iron articles to be air-cooled or water-cooled. (Refer to Fig. 2). Here, the retaining or maintaining periods were varied somewhat depending on the quantities of the products charged into the heat-treating furnace.

[37] Table 2

Comparison of mechanical properties depending on tempering temperatures.

Temper.t emp.	Con ven(not ht treat ed)	250°C	280°C	300°C	320°C	360°C	380°C	400°C	420°C	450°C
Tens.str.(kg/mm ²)	20~3 0	160~1 80	150~1 75	150~1 70	140~1 60	110~1 30	100~1 20	95~11 0	90~10 0	70~85
2% yield strength(kg/mm ²)	-	120~1 40	110~1 30	110~1 30	105~1 25	90~10 0	80~90	60~70	45~55	35~50
Elong.(1~2	2~5	3~6	5~8	6~9	7~11	9~15	7~12	5~9	3~7

%)										
Hardness (HB)	170~ 190	450~4 90	430~4 50	380~4 30	340~3 80	310~3 60	280~3 30	260~2 90	250~2 80	230~2 70
Impact v.(kg/cm ²)	-	3~5	4~7	6~8	7~9	10~12	10~15	10~12	7~9	5~6
Abrasion Hard.(rel tohomol og. stl)	-	2~3 times	2~3 times	2~3 times	2~3 times	2~3 times	2~3 times	2~3 times	2~3 times	1~2 times

[38]

[39]

The annealing heat treatment as indicated in Fig. 3 refers to the pre-treatment conducted before the austempering heat-treatment of the spherical graphite cast iron. The brake disks for vehicles according to the invention are round flat circular disks as shown in Fig. 1. The spherical graphite cast iron as the raw material of brake disks is of cast structures, which were formed after the hot molted bath was cooled, and therefore has considerable internal stress generated in the course of heating and cooling. Accordingly, in the case of directly austempering heat-treating the spherical graphite cast iron product having been cast, thermal stains would tend to be caused during heating due to the geometric imperfection and internal stresses so as to disfavor after-machining. Further, In that case, the temperature of brake disks would rise due to the friction with brake pads at the time of braking a vehicle, with the result that the frictional braking force would fall.

[40]

Therefore, in order to resolve such a problem, there is conducted an annealing heat treatment, wherein the brake disks for vehicles of spherical graphite cast iron are heated so that the core part reaches 700 ~ 950°C before the austempering heat treatment and maintained at that temperature for 10 min. ~ 1 hr., followed by air-cooling or furnace-cooling. (See Fig. 3). Here, the retaining or maintaining periods may be varied somewhat depending on the quantities of the products charged into the heat-treating furnace. By conducting the annealing process as the pre-treatment for relieving the internal stress of cast structures, the thermal strain of products during austempering heat treatment is minimized to facilitate the after-machining and the thermal strain is prevented even under the friction heat of brake disks with brake pads when braking vehicles, whereby frictional braking power can be preserved.

[41]

The heat treatment for removing machining stress as depicted in Fig. 4 refers to the

after-treatment performed after the austempering heat treatment and machining of the spherical graphite cast iron article are finished. As shown in Fig. 1, the brake disk for vehicle according to the invention is subjected to the machining operation onto contacting surfaces 2 with brake pads 1, an assembling surface 3 on a wheel and many through-holes for bolts 4, covering a considerably wide area, so that there remains considerable machining stress on the machined surfaces, which residual stress causes the product to minutely distort with time, or causes so-called age-strain. The brake disks so age-strained undergo the decrease in their contacting surfaces with brake pads to cause the curtailment of braking capability. Therefore, in order to resolve such a problem, there is conducted the machining stress relieving heat treatment, wherein the brake disk products for vehicles, on which machining has been completed, are heated so that the core part reaches 300 ~ 600°C and subsequently maintained at that temperature for 10 min. ~ 1 hr. and then air-cooled or water-cooled. (See Fig. 4). Here, the retaining or maintaining periods may vary somewhat depending on the quantities of the products charged into the heat-treating furnace. Through this after-treatment for removing machining stress from the products, the strain of the products after the machining operation is minimized and the effective friction area is preserved, preventing the reduction in braking capability.

[42]

[43] INDUSTRIAL APPLICABILITY

[44] As described above, according to the invention, the effect of reducing the weight of vehicle is realized due to the decreased thickness of product and nevertheless the mechanical properties like wear resistance, toughness and impact strength are excellent so as to extend the service life of the product, by using spherical graphite cast iron after heat treating for manufacturing the brake disk for vehicle, in comparison to the conventional grey cast iron product manufactured with a large thickness to compensate for insufficient toughness and weak impact strength.

[45] Particularly, referring to the effect of reducing the vehicle weight, one brake disk according to the invention is lighter than the conventional one by 3 ~ 5 kg and so the reduction in weight will amount to 6 ~ 10 kg when both wheels are mounted with the brake disks according to the invention, whereby the effect of reducing the vehicle weight equivalent to 60 ~ 100 kg would be achieved, in conjunction with evident fuel economy, on the ground that the reduction in the weight of the wheels as the final power transmitting means in a vehicle corresponds to the weight reduction as increased by 10 times for the vehicle in the practical effect, e.g. 1 kg of reduction in the weight of wheels will correspond to 10 kg of reduction in the weight of vehicle as a whole.

[46] Further, the spherical graphite cast iron according to the invention has the advantage of preventing the environmental pollution due to Cr, because the additives

like Cr for improving the hardening ability are not required due to the excellent mechanical properties through heat treatment such as wear resistance, toughness and impact strength, and the Cr plating for appearance is not needed due to the sufficiently elegant appearance compared to the grey cast iron, in contrast to the conventional grey cast iron, wherein the Cr component, used as additive for casting to improve the resistance to heat and wear due to lacking heat treatment and used as plating for aesthetic surface of the product, is emitted to the atmosphere due to friction with brake pads at the time of braking vehicles to cause the air pollution.

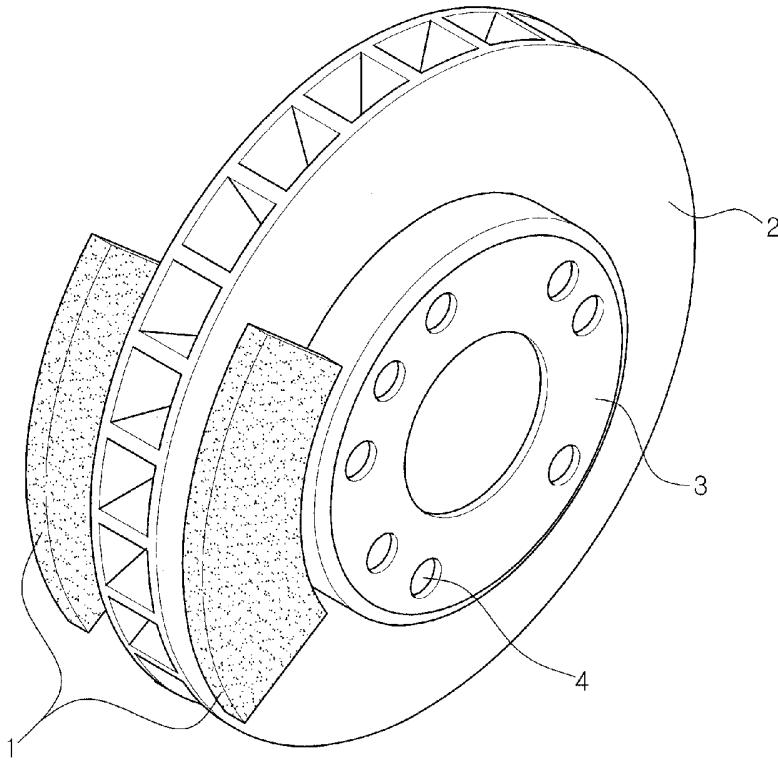
[47] In addition, the thermal strain of products during the austempering heat treatment is minimized according to the invention to facilitate the after-machining, by virtue of the annealing treatment as the pre-treatment prior to the austempering treatment to relieve the internal stress in the cast structures, and thermal strain due to the frictional heat generated between brake disks and brake pads at the time of braking is prevented from taking place so as to preserve the braking capability.

[48] Furthermore, the strain of products after the machining is minimized as well so as to maintain the frictional area with braking pads and thereby prevent the braking capability from falling, by virtue of the after-machining following the perfection of machining on brake disks for vehicles for removing the machining stress from the products.

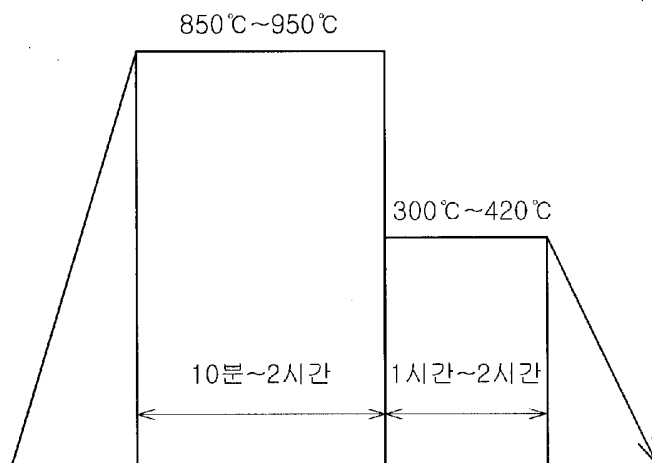
Claims

- [1] a method for manufacturing brake disks for vehicles, which comprises the steps of: heating spherical graphite cast iron in the form of a brake disk for vehicle in a non-oxidizing atmosphere so that the core of the cast iron material reaches 850~950°C, said spherical graphite cast iron including 3.0 ~ 3.8 wt.% of C, 2.0 ~ 2.8 wt.% of Si, 0.1 ~ 0.4 wt.% of Mn, 0.01 ~ 0.08 wt.% of P, 0.001 ~ 0.02 wt.% of S and 0.01 ~ 0.05 wt.% of Mg and optionally including either all or two out of the three components of 0.15 ~ 0.4 wt.% of Mo, 0.5 ~ 1.2 wt.% of Cu and 0.6 ~ 2.0 wt.% of Ni, and the balance of Fe as well as inevitable impurity, said spherical graphite cast iron consisting of 2 ~ 40 % of ferrite structure and 60 ~ 98 % of pearlite structure, said spherical graphite cast iron having over 70 % of spherizing rate, said spherical graphite cast iron having the number of graphites at over 100/mm²; after maintaining for 10 min. ~ 2 hr. after said temperature of 850~950°C is reached, maintaining for 1 ~ 2 hr. in a low-temperature salt bath furnace or oil furnace maintained at 300 ~ 420 °C and stirred; and subjecting the brake disk of graphite cast iron so treated to air-cooling or water-cooling.
- [2] The method for manufacturing brake disks for vehicles of claim 1, wherein prior to the above-described heat treatment, the core of the above-described material is heated to 700 ~ 950 °C and maintained at the same temperature for 10 min. ~ 1 hr. followed by air-cooling or furnace-cooling.
- [3] The method for manufacturing brake disks for vehicles of claim 1, wherein after the above-described heat treatment, the above-described material is machined to form surface of contact with brake pads, surface for mounting on wheel and holes for receiving bolts, heated so that the core of material reaches 300 ~ 600°C and maintained at the same temperature for 10 min. ~ 1 hr. and thereafter the material is air-cooled or water-cooled.

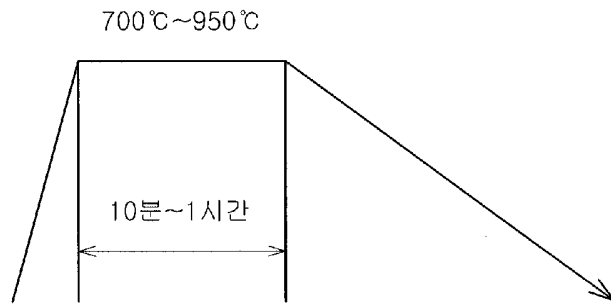
[Fig. 1]



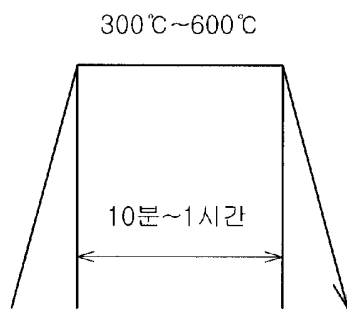
[Fig. 2]



[Fig. 3]



[Fig. 4]



PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference FA5P0819	FOR FURTHER ACTION see Form PCT/ISA/220 as well as, where applicable, item 5 below.	
International application No. PCT/KR2005/002747	International filing date (<i>day/month/year</i>) 19 AUGUST 2005 (19.08.2005)	(Earliest) Priority Date (<i>day/month/year</i>) 23 AUGUST 2004 (23.08.2004)
Applicant LEE, Kwang Rae		

This International search report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This international search report consists of a total of 3 sheets.

It is also accompanied by a copy of each prior art document cited in this report.

1. **Basis of the report**

a. With regard to the **language**, the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.

The international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).

b. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, see Box No. I.

2. **Certain claims were found unsearchable** (See Box No. II)

3. **Unity of invention is lacking** (See Box No. III)

4. With regard to the **title**,

the text is approved as submitted by the applicant.

the text has been established by this Authority to read as follows:

5. With regard to the **abstract**,

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the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box No. IV. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. With regard to the drawings,

a. the figure of the **drawings** to be published with the abstract is Figure No. 2

as suggested by the applicant.

because the applicant failed to suggest a figure.

because this figure better characterizes the invention.

b. none of the figure is to be published with the abstract.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR2005/002747**A. CLASSIFICATION OF SUBJECT MATTER****IPC7 C22C 38/02**

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)

IPC7 C22C 38/02, C22C 37/00, C22C 37/04, C22C 33/08

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

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

Patent and Utility Search System at KIPO.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 63192821 A (RAILWAY TECHNICAL RES INST., MEIDENSHA ELECTRIC MFG CO. LTD., MEIDEN CHUKO KK) 10 AUGUST 1988 See the whole document	1 - 3
A	JP 60215737 A (JAPAN NATIONAL RAILWAYS, KAWASAKI HEAVY IND. LTD.) 29 OCTOBER 1985 See the whole document	1 - 3
A	WO 99/19525 A (CAMCAST INDUSTRIES PTY. LTD.) 22 APRIL 1999 See the whole document	1 - 3
A	JP 61281848 A (HONDA MOTOR CO. LTD.) 12 DECEMBER 1986 See the whole document	1 - 3

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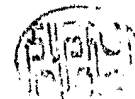
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