[Designation of Document] Abstract

[Abstract]

[Problem]

A tire composition for motorcycle, that is low in rolling resistance, can contribute to low fuel consumption and is excellent in rigid feeling when turning, and a tire for motorcycle are provided.

[Means for Resolution]

The tire composition for motorcycle is that a value of loss tangent tan δ at a measurement temperature of 60°C is 0.182 or less, a value obtained by the following formula (1) from a value of loss tangent tan δ at a measurement temperature of -30°C and a value of dynamic complex modulus E* at -30°C is 1.4 [MPa^{-1}] or more, a value of dynamic complex modulus E* at a measurement temperature of 30°C is 9.6 [MPa] or more, and a value of dynamic complex modulus E* at a measurement temperature of 60°C is 6.9 [MPa] or more.

Physical property index = $10^4 \times \tan \delta / E^*$ (1)

[Selected Drawing] None

[Designation of Document] Claims

[Claim 1]

A tire composition for motorcycle wherein

a value of loss tangent tan δ at a measurement temperature of 60°C is 0.182 or less,

a value obtained by the following formula (1) from a value of loss tangent tan δ at a measurement temperature of -30°C and a value of dynamic complex modulus E* at -30°C is 1.4 [MPa^{-1}] or more,

a value of dynamic complex modulus E* at a measurement temperature of 30°C is 9.6 [MPa] or more, and

a value of dynamic complex modulus E* at a measurement temperature of 60°C is 6.9 [MPa] or more.

$$\text{Physical property index} = 10^4 \times \tan\delta / E^* \qquad (1)$$

[Claim 2]

The tire composition for motorcycle according to claim 1, wherein

a value of loss tangent tan δ at a measurement temperature of 60°C is 0.155 or less,

a value obtained by the formula (1) is 2.2 [MPa^{-1}] or more,

a value of dynamic complex modulus E* at a measurement temperature of 30°C is 10.1 [MPa] or more, and

a value of dynamic complex modulus E* at a measurement temperature of 60°C is 7.4 [MPa] or more.

[Claim 3]

The tire composition for motorcycle according to claim 1, wherein

the value of loss tangent tan δ at a measurement temperature of 60°C is 0.128 or less.

[Claim 4]

The tire composition for motorcycle according to claim 1, wherein

the value of dynamic complex modulus E* at a measurement temperature of -30°C is 1140 [MPa] or less, and

the value of loss tangent tan δ at a measurement temperature of -30°C is 0.251 or more.

[Claim 5]

The tire composition for motorcycle according to claim 1 or 2, comprising a polymer part constituted by containing natural rubber and an end-modified polymer, and surface-treated silica.

[Claim 6]

A tire for motorcycle, having a tread part (5), a shoulder part (6) and a side wall part (4), and being capable of grounding in a grounding part (S) containing the tread part and the shoulder part, wherein

the grounding part has a round shape as a whole, and

at least the whole grounding part is constituted of the tire composition for motorcycle according to any one of claims 1 to 5.

[Claim 7]

The tire for motorcycle according to claim 6, wherein in addition to the grounding part, the side wall part is constituted of the tire composition for motorcycle according to any one of claims 1 to 5.

Dated this 08 day of March 2013

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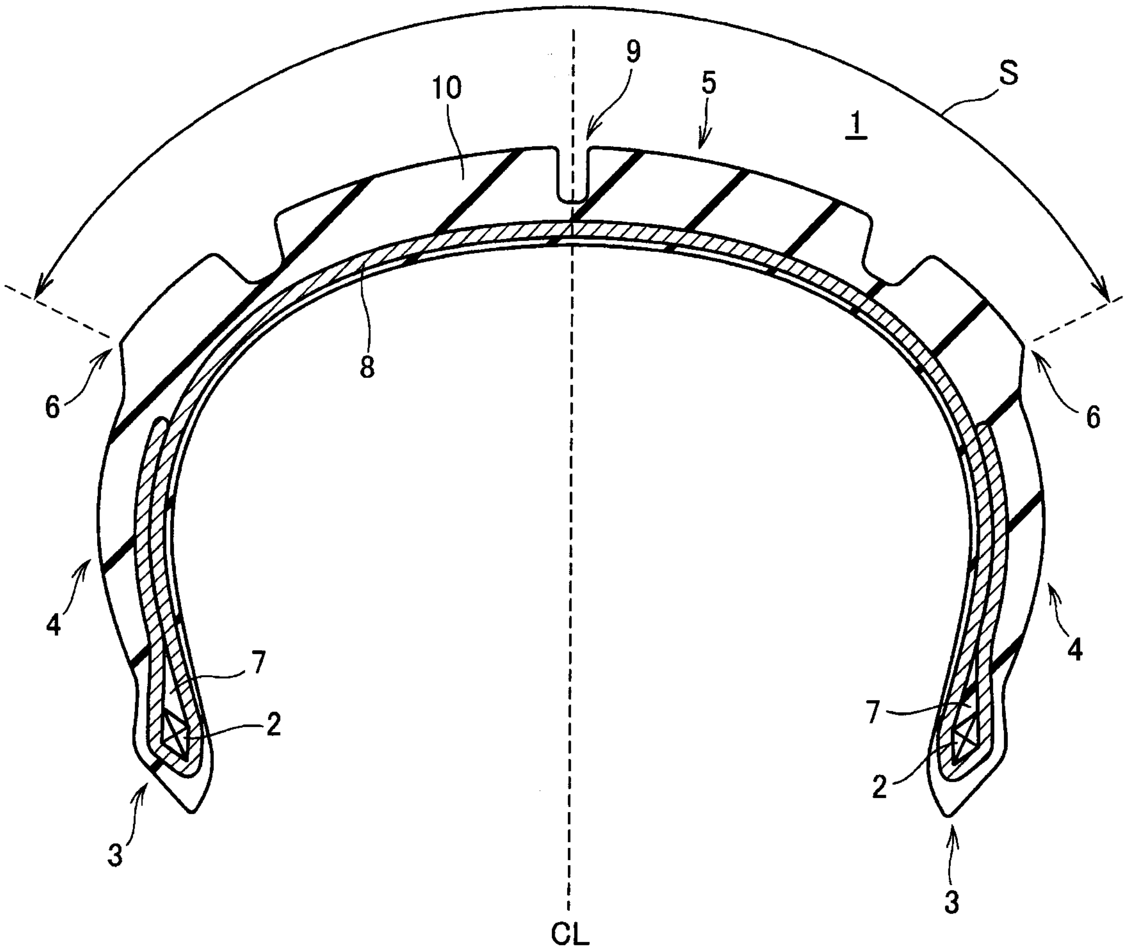
[Designation of Document] Drawings

[Fig. 1]



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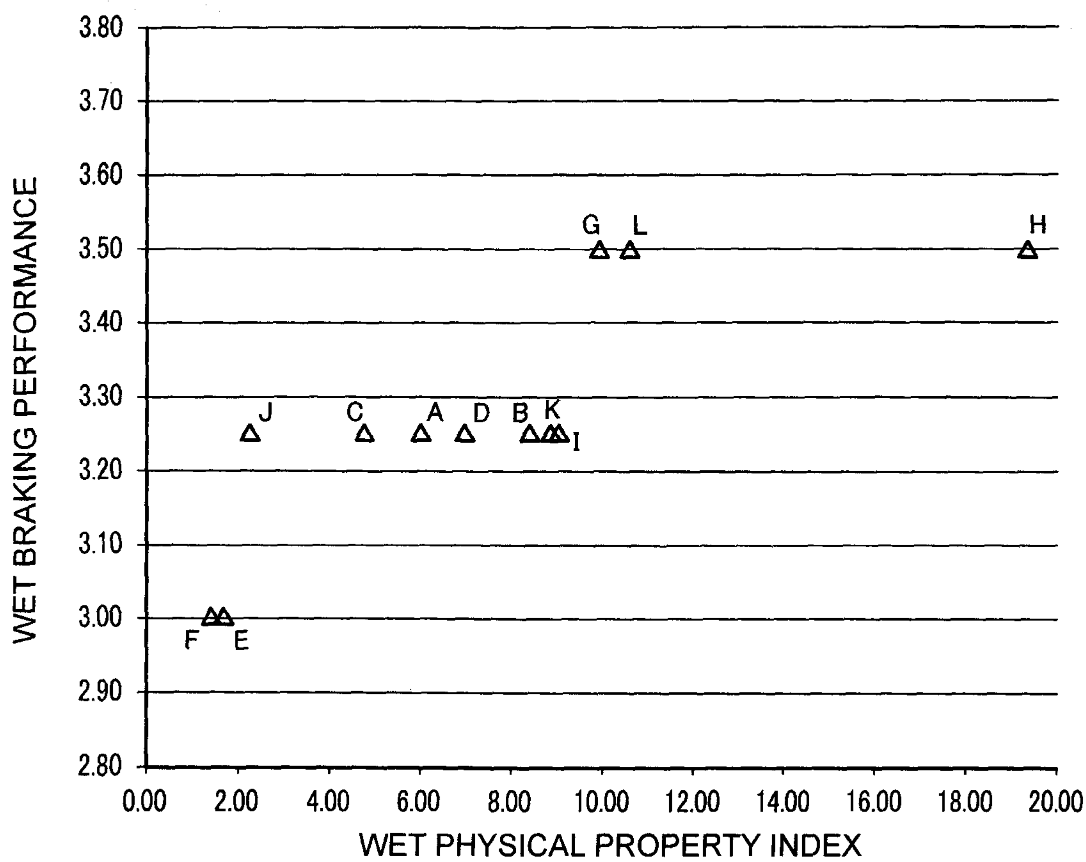
[Fig. 2]



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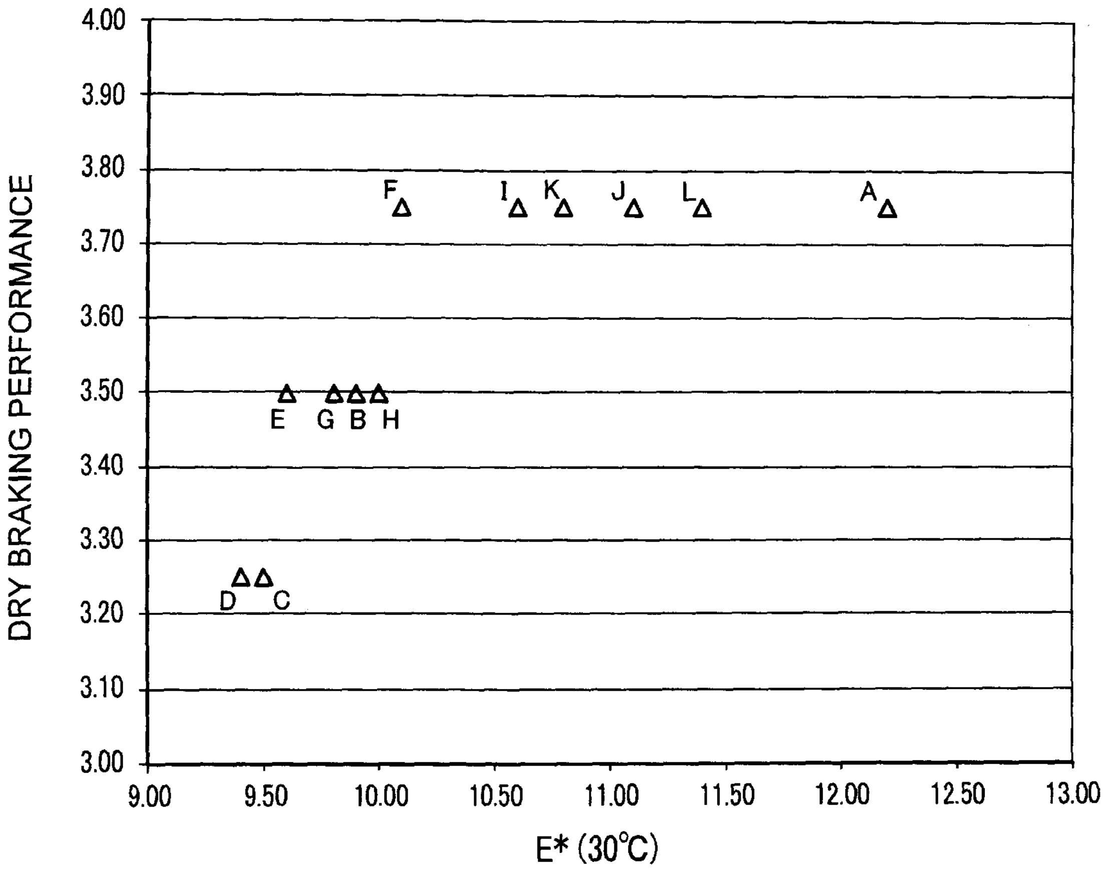
[Fig. 3]



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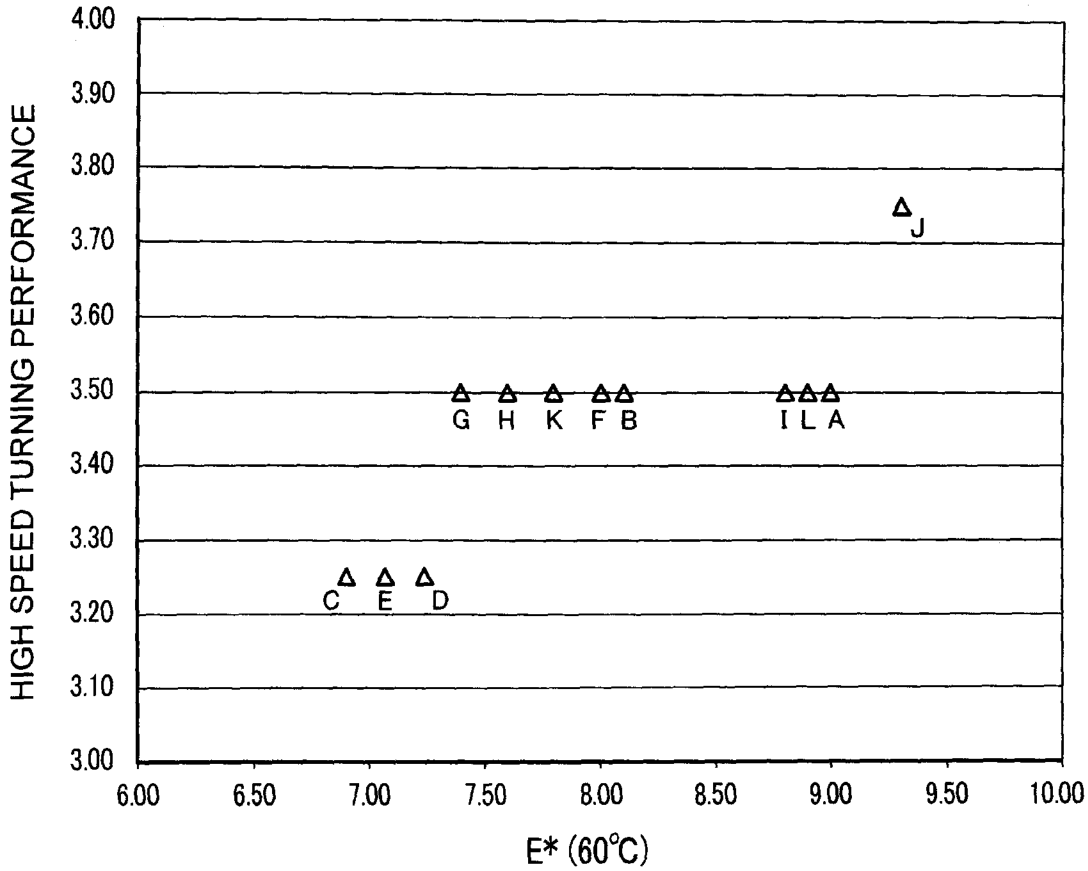
[Fig. 4]



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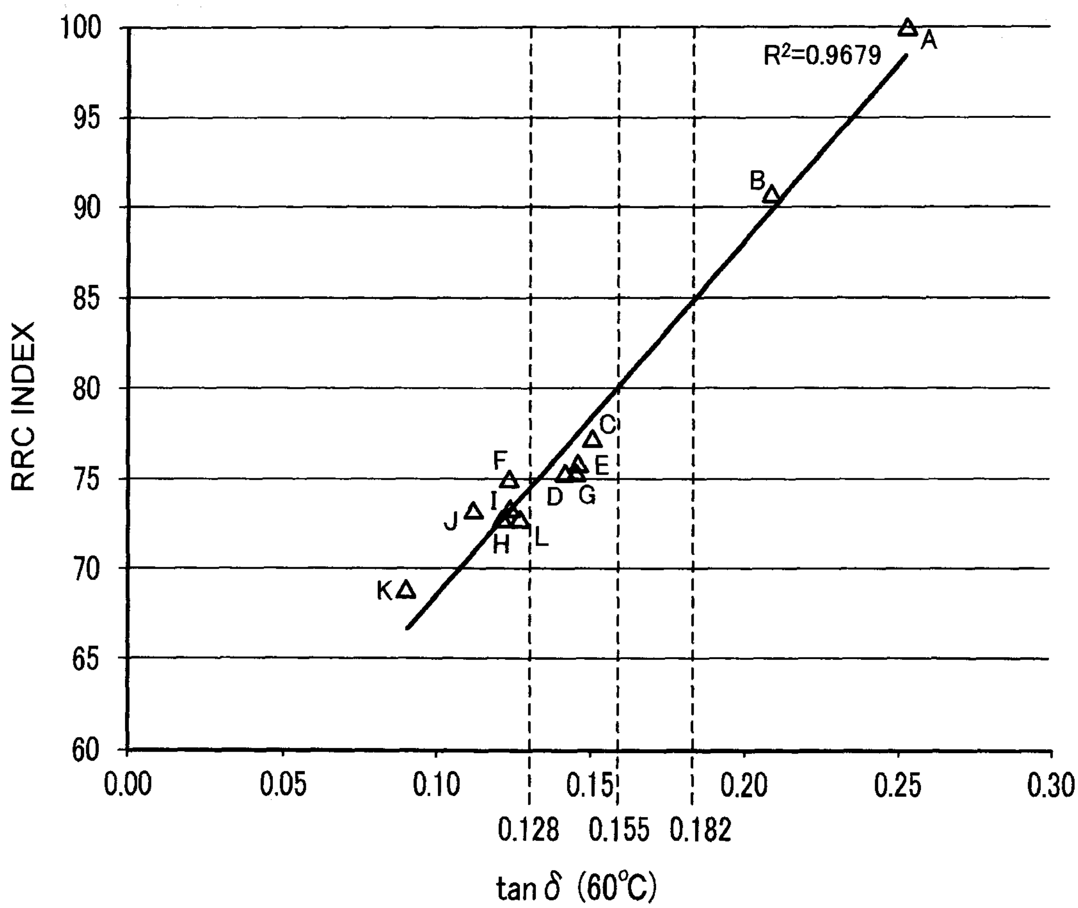
[Fig. 5]



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"Translation for application"

[Designation of Document] Specification

[Title of the Invention] Tire Composition for Motorcycle and Tire for Motorcycle

[Technical Field]

[0001]

The present invention relates to a tire composition for motorcycle and a tire for motor cycle.

[Background Art]

[0002]

Recently, with the increased interest in environmental problems, a tire that can achieve low fuel consumption is required, and a tire having reduced rolling resistance is proposed (for example, see Patent Document 1). The relationship between physical properties of a rubber composition for a tire and tire performances are conventionally studied, and Patent Document 1 discloses an example in which ranges of tan δ at 60°C and tan δ at 0°C are defined, as a tire composition for four-wheel vehicles, securing wet performance and abrasion resistance together with reduced rolling resistance.

[Prior Art Literature]

[Patent Document]

[0003]

[Patent Document 1] JP-A-5-25327

[Summary of the Invention]

[Problems that the Invention is to Solve]

[0004]

Motorcycle turns by inclining its body, thereby generating camber thrust. Therefore, a tire for motorcycle is required to have turning performance different from that of a tire for four-wheel vehicles. Specifically, the tire for motorcycle is required to have rigidity feeling in a satisfactory level when turning, and the same is applied to a fuel-efficient tire. For this reason, a tire composition for motorcycle, having low rolling resistance, capable of contributing to low fuel consumption and having excellent rigidity feeling when turning has been desired.

The present invention has been made in view of the above circumstances, and has an object to provide a tire composition for motorcycle, having low rolling resistance, capable of contributing to low fuel consumption and having excellent rigidity feeling when turning, and a tire for motorcycle.

[Means for Solving the Problems]

[0005]

To achieve the above object, the tire composition for motorcycle according to the present invention is that a value of loss tangent tan δ at a measurement temperature of 60°C is 0.182 or less, a value obtained by the following formula (1) from a value of loss tangent tan δ at a measurement temperature of -30°C and a value of dynamic complex modulus E* at -30°C is 1.4 [MPa^{-1}] or more, a value of dynamic complex modulus E* at a measurement temperature of 30°C is 9.6 [MPa] or more, and a value of dynamic complex modulus E* at a measurement temperature of 60°C is 6.9 [MPa] or more.

$$\text{Physical property index} = 10^4 \times \tan\delta / E^* \quad (1)$$

[0006]

According to the present invention, a tire for motorcycle excellent in both braking performance on wet road and dry road and rigidity feeling when turning, and capable of achieving low fuel consumption can be realized.

[0007]

Furthermore, the tire composition for motorcycle is preferably a tire composition for motorcycle, characterized in that a value of loss tangent tan δ at a measurement temperature of 60°C is 0.155 or less, a value obtained by the formula (1) is 2.2 [MPa^{-1}] or more, a value of dynamic complex modulus E* at a measurement temperature of 30°C is 10.1 [MPa] or more, and a value of dynamic complex modulus E* at a measurement temperature of 60°C is 7.4 [MPa] or more.

In this case, a tire for motorcycle, excellent in both braking performance on wet road and dry road and rigidity feeling when turning, and capable of achieving lower fuel consumption can be realized.

[0008]

The tire composition for motorcycle is preferably that the value of loss tangent tan δ at a measurement temperature of 60°C is 0.128 or less.

When the tire composition for motorcycle is used, further lower fuel consumption can be achieved.

[0009]

Furthermore, the tire composition for motorcycle is preferably that a value of dynamic complex modulus E* at a measurement temperature of -30°C is 1140 [MPa] or less, and a value of loss tangent tan δ at a measurement temperature of -30°C is 0.251 or more.

In this case, a tire for motorcycle excellent in braking performance on wet road, having the correlation with the physical property index obtained by the formula (1) can be realized.

[0010]

Furthermore, the tire composition for motorcycle is more preferably a composition that contains a polymer part constituted by containing natural rubber and an end-modified polymer, and surface-treated silica.

In this case, a tire for motorcycle excellent in braking performance and rigidity feeling when turning and capable of achieving low fuel consumption can easily be produced using natural rubber having excellent availability.

[0011]

The polymer part is the sum of a rubber and a synthetic rubber component, contained in a tire composition, and contains, for example, natural rubber and a diene rubber (a butadiene rubber, a styrene-butadiene rubber and the like).

[0012]

The tire for motorcycle according to the present invention is a tire for motorcycle, having a tread part, a shoulder part and a side wall part, and capable of grounding in a grounding part containing the tread part and the shoulder part, characterized in that the grounding part has a round shape as a whole, and at least the whole grounding part is constituted of the tire composition for motor cycle.

According to the present invention, the whole grounding part is constituted of a composition exhibiting low fuel consumption and excellent braking performance and turning performance. Therefore, a tire for motorcycle having excellent running performance when straightly running and when turning, and capable of realizing low fuel consumption can be provided. Furthermore, the grounding part has a round shape as a whole, and the round-shaped grounding part is constituted of the tire composition according to the present invention, thereby exhibiting excellent rigidity feeling when turning.

Furthermore, in the tire for motorcycle, in addition to the grounding part, the side wall part may be constituted of the tire composition for motorcycle. In this case, the tread part, the shoulder part and the side wall part can be formed by the same material as a unit, and a tire for motorcycle involving small number of steps and excellent in mass productivity can be provided.

Furthermore, the tire for motorcycle may be a bias tire. In this case, a tire for motorcycle, excellent in braking performance and turning performance and capable of achieving low fuel consumption can be provided at low costs.

[Advantage of the Invention]

[0013]

According to the present invention, a tire for motorcycle excellent in both braking performance on wet road and dry road and turning performance, and capable of achieving low fuel consumption can be realized.

Furthermore, by containing the polymer part and the surface-treated silica, a tire for motorcycle excellent in both braking performance on wet road and dry road and turning performance, and capable of achieving low fuel consumption can easily be produced.

Furthermore, the tire has the tread part, the shoulder part and the side wall part, and the whole grounding part containing the tread part and the shoulder part is constituted of the composition exhibiting low fuel consumption and good characteristics in braking performance and turning performance. Therefore, a tire for motorcycle, having excellent running performance when straightly running and when turning can be provided.

Furthermore, the grounding part has a round shape as a whole, and the round-shaped grounding part is constituted of the tire composition of the present invention, thereby exhibiting excellent turning performance.

Furthermore, the tread part, the shoulder part and the side wall part can be formed as a unit by the same material, and a tire for motorcycle involving small number of steps and having excellent mass productivity can be provided.

Furthermore, by forming a bias tire, a tire for motorcycle, excellent in braking performance and turning performance and capable of achieving low fuel consumption can be provided at low costs.

[Brief Description of the Drawings]

[0014]

Fig. 1 is a cross-sectional view of the tire according to an embodiment of the present invention.

Fig. 2 is a diagram showing characteristics of tires of Examples and Comparative Examples.

Fig. 3 is a diagram showing characteristics of tires of Examples and Comparative Examples.

Fig. 4 is a diagram showing characteristics of tires of Examples and Comparative Examples.

Fig. 5 is a diagram showing characteristics of tires of Examples and Comparative Examples.

[Mode for Carrying out the Invention]

[0015]

The embodiment of the present invention is described below by reference to the drawings.

Fig. 1 is a cross-sectional view of a tire 1 according to one embodiment of the present invention. The tire 1 shown in Fig. 1 is a tire to be mounted to a motorcycle.

The tire 1 is equipped with a pair of bead parts 3 having a bead core 2 embedded therein, a pair of side wall parts 4 extending outside in a tire radial direction, and a tread part 5 extending across both side wall parts 4 and 4. The boundary between the tread part 5 and the side wall 4 is a shoulder part 6 slightly projecting laterally.

Furthermore, in the tire 1, a plurality of reinforcing elements such as high modulus textile cords arranged in parallel such that an angle to a equatorial plane CL of the tire is from 65 to 90° are covered with a rubber to constitute a carcass 8, and the carcass 8 is wound up around a bead core 2 such as a non-stretchable ring body and a bead apex 7 adjacently arranged thereon toward the outside from the inside in a tire width direction, and locked. The tire 1 is a bias tire, and is not equipped with a belt extending in a circumferential direction of a tire.

[0016]

The tire 1 is that the tread part 5 centering a center region 9 including the equatorial plane CL of a tire constitutes a grounding part S together with the shoulder part 6 located in the boundary between the tread part 5 and the side wall part 4. In the state that a motor cycle having the tire 1 mounted thereto straightly runs, the tread part 5, particularly the center region 9, is mainly grounded, and during turning, the edge of the tread part 5 and the shoulder part 6 are mainly grounded. For this reason, the grounding part S has a round shape as a whole.

[0017]

The tire 1 to which the present invention has been applied achieves low fuel consumption and is excellent in braking performance and turning performance, as described hereinafter. It is known that low fuel consumption of a tire can be achieved by suppression of rolling resistance, and the present inventors made investigations using RRC index as an index of rolling resistance. Furthermore, the present inventors made investigations on the respective braking performances on dry road and wet road, and further made investigations on turning performance.

[0018]

Modulus of the grounding part S of the tire 1 affects fuel consumption as described before. The present inventors have specifically found that loss tangent tan δ at a measurement temperature of 60°C (hereinafter referred to as tan δ (60°C); the same applies to 30°C and -30°C) has a correlation with the RRC index.

The present inventors have further found that dynamic complex modulus E* of the grounding part has strong correlation with turning performance of a tire, and have particularly found that with increasing dynamic complex modulus E* at 60°C (hereinafter referred to as E* (60°C); the same applies to -30°C and 30°C), rigidity feeling of a tire when turning is increased, and turning performance is increased.

The present inventors have further found that E* (30°C) has a correlation with braking performance on dry road, and a value obtained by the formula (1) from a value of tan δ (-30°C) and a value of E* (-30°C) has strong correlation with braking performance on wet road.

By using a tire composition showing suitable tan δ and E* at each temperature, the tire 1 excellent in low fuel consumption and additionally excellent in braking performance and turning performance is realized.

[0019]

The tire composition constituting the tire 1 of the present invention is characterized in that a value of tan δ (60°C) is 0.182 or less, a value obtained by the following formula (1) from a value of tan δ (-30°C) and a value of E* (-30°C) is 1.4 [MPa^{-1}] or more, a value of E* (30°C) is 9.6 [MPa] or more, and a value of E* (60°C) is 6.9 [MPa] or more.

Physical property index = $10^4 \times \tan \delta / E^*$ (1)

[0020]

The physical property index obtained by the above formula (1) is increased with decreasing E* and increasing tan δ. Low E* means that adhesion to a road surface of the grounding part S is high. On the other hand, high tan δ means that energy loss when braking after contact between the grounding part S and a road surface is large. The value at a measurement temperature of -30°C correlates with the characteristic that the grounding part S is difficult to hold a road surface. From those findings, the present inventors have clarified that in the case that the physical property index obtained by the above formula (1) is 1.4

[MPa^{-1}] or more, excellent braking performance on wet road is exhibited.

Particularly, they have clarified that in the case that the physical property index of the above formula (1) is 2.2 [MPa^{-1}] or more, the braking performance on wet road is further increased. They have further clarified that in the case that the physical property index of the above formula (1) is 1.4 [MPa^{-1}] or more, the value of E* (-30°C) is 1140 [MPa] or less, and the value of tan δ (-30°C) is 0.251 or more, the braking performance on wet road is still further increased.

Furthermore, the value of E* (30°C) correlates with the characteristics in the state that the grounding part S relatively easily holds a road surface. The present inventors have clarified that in the case that the value of E* (30°C) is 9.6 [MPa] or more, excellent braking performance on dry road is exhibited. They have further clarified that in the case that the value of E* (30°C) is 10.1 [MPa] or more, the braking performance on dry road is further increased.

In addition, it is known that the RRC index has a correlation with loss tan δ that is an index of modulus of a grounding part, and the RRC index is decreased with decreasing tan δ (60°C). In this point, they have clarified that in the case that the value of tan δ (60°C) is 0.182 or less, low fuel consumption can be realized. They have further clarified that in the case that the value of tan δ (60°C) is 0.155 or less, lower fuel consumption can be realized. They have further clarified that in the case that the value of tan δ (60°C) is 0.128 or less, further lower fuel consumption can be realized.

They have clarified that in the case that the value of E* (60°C) is 6.9 [MPa] or more, excellent high speed turning performance is obtained in addition to low fuel consumption. They have further clarified that in the case that the value of E* (60°C) is 7.4 [MPa] or more, further excellent high speed turning performance is obtained.

[0021]

The tire 1 has the tread part 5, the shoulder part 6 and the side wall parts 4 and 4, and is formed into a shape that can be grounded in the grounding part S including the tread part 5 and the shoulder part 6, and at least the whole grounding part S is constituted of the tire composition of the present invention. By this constitution, the whole grounding part S exhibits good characteristics in all of low fuel consumption, braking performance and turning performance. Therefore, a tire for motorcycle having excellent running performance when straightly running and when turning can be provided. Furthermore, the side wall parts 4 and 4 together with the grounding part S may be constituted of the tire composition of the present invention. In this case, the tire 1 can be molded as a unit after winding up a carcass 8 around the bead core 2 and a bead apex 7. Thus, the number of steps is small, and mass productivity is excellent.

Furthermore, when the grounding part S has a round shape as a whole and the round-shaped grounding part S is constituted of the tire composition of the present invention, excellent rigidity feeling is exhibited when turning. Furthermore, because the tire 1 is a bias tire that is not equipped with a steel belt, the characteristics of the tire composition constituting the ground part S is strongly reflected to the characteristics of the grounding part S of the tire 1. For this reason, by constituting the grounding part S with the tire composition of the present invention, the tire 1 excellent in braking performance and turning performance and capable of achieving low fuel consumption can be realized.

[0022]

The above-described embodiment merely shows a part of the embodiments of the present invention, and those constitutions can mutually be combined, the same constitution as in the conventional tire can be made and various modifications can be made, without departing from the spirit and scope of the present invention.

[Example]

[0023]

Examples of the present invention are described in detail below, but it should be understood that the invention is not construed as being limited to those Examples.

In the following Examples, test production and evaluation were made regarding Examples 1 to 8 to which the present invention was applied, and Comparative Examples 1 to 4 as comparison.

Specification of each Example, measurement results of physical properties, and evaluation are shown in Table 1. The symbols A to L shown in Table 1 show correspondences to plots in the drawings described hereinafter.

[0024]

[Table 1]

Table 1

		Comparative Example 1 (A)	Comparative Example 2 (B)	Comparative Example 3 (C)	Comparative Example 4 (D)	Example 1 (E)	Example 2 (F)	Example 3 (G)	Example 4 (H)	Example 5 (I)	Example 6 (J)	Example 7 (K)	Example 8 (L)
Formulation (parts by weight)	Natural rubber*1				70	60	60	35	50	35	70		20
	E-SBR (No. 1)*2	137.5	137.5										
	E-SBR (No. 2)*3			100									
	E-SBR (No. 1)*4				30	40	40	50	35	50	30		
	E-SBR (No. 2)*5											85	65
	BR*6							15	15	15		15	15
	Carbon black*7	100	75	50	50	50	50	50	50	50	50		
	Silica*8											60	80
	Silane coupling agent*9											4.8	6.4
	Zinc flower*10	3	3	3	3	3	3	3	3	3	3	3	3
	Stearic acid	1	1	1	1	1	1	1	1	1	1	1	1
	Aroma oil	32.5	8	15									
	Naphthene oil												20
	Anti-aging agent (No. 1)*11	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
	Anti-aging agent (No. 2)*12	2	2	2	2	2	2	2	2	2	2	2	2
	Wax*13	2	2	2	2	2	2	2	2	2	2	2	2
	Zinc fatty acid*14											3	3
	Sulfur	2	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	2.3	1.7	1.7
	Vulcanization accelerator (No. 1)*15	1.5	0.7	0.7	0.7	0.7	1.7	0.7	1.7	1.7	1.7	2.2	2.2
	Vulcanization accelerator (No. 2)*16											0.75	0.75
Physical properties of material													
RRC physical property index		0.251	0.208	0.150	0.141	0.145	0.123	0.144	0.121	0.123	0.111	0.090	0.126
DRY physical property index		12.2	9.9	9.5	9.4	9.6	10.1	9.8	10.0	10.6	11.1	10.8	11.4
WET physical property index		6.0	8.4	4.8	7.0	1.7	1.4	10.0	19.5	9.0	2.2	8.9	10.7
High speed turning performance physical property index		9.2	8.1	6.9	7.2	7.1	8.0	7.4	7.6	8.8	9.3	7.8	8.9
E* (-30°C)/Mpa		623	452	800	522	1324	1543	557	341	607	1140	1000	740
tan δ (-30°C)		0.375	0.381	0.381	0.365	0.221	0.212	0.557	0.665	0.548	0.251	0.889	0.789
Tire performance (index)													
RRC index		100	91	77	75	76	75	75	73	73	73	69	73
DRY braking performance		3.75	3.5	3.25	3.25	3.5	3.75	3.5	3.5	3.75	3.75	3.75	3.75
WET braking performance		3.25	3.25	3.25	3.25	3	3	3.5	3.5	3.25	3.25	3.25	3.5
High speed turning performance		3.5	3.5	3.25	3.25	3.25	3.5	3.5	3.5	3.5	3.75	3.5	3.5

[0025]

*1: SIR (Standard Indonesian Rubber)

*2: Nipol (registered trademark) 1723, manufactured by Zeon Corporation

*3: Nipol (registered trademark) 1502, manufactured by Zeon Corporation

*4: Nipol (registered trademark) NS116R, manufactured by Zeon Corporation

*5: Nipol (registered trademark) NS616, manufactured by Zeon Corporation

*6: Nipol (registered trademark) BR1220, manufactured by Zeon Corporation

*7: Seast KH, manufactured by Tokai Carbon Co., Ltd.

*8: Zeosil (registered trademark) 115GR, manufactured by Rhodia

*9: Si-75, manufactured by Evonic-Degussa

*10: Zinc oxide third class

*11: Nocrac 6C, manufactured by Ouchi Shinko Chemical Industrial Co., Ltd.

*12: Nocrac 224, manufactured by Ouchi Shinko Chemical Industrial Co., Ltd.

*13: Microcrystalline wax

*14: Struktol (registered trademark) EF44, manufactured by Struktol Company of America

*15: Nocceler NS-P, manufactured by Ouchi Shinko

Chemical Industrial Co., Ltd.

*16: Nocceler D, manufactured by Ouchi Shinko Chemical Industrial Co., Ltd.

[0026]

In Table 1, RRC physical property index is loss tangent tan δ (60°C) at 60°C. DRY physical property index is E* (30°C), and WET physical property index is a physical property index obtained by the following formula (1). Physical property index of high speed turning performance is E* (60°C). Furthermore, unit of E* is [MPa].

WET physical property index = $10^4 \times \tan\delta / E^*$ (1)

[0027]

A tire for motorcycle was produced experimentally using a tire composition of each of Examples and each of Comparative Examples, and was used in the test. The tire experimentally produced is a bias tire having a size of 80/90-17, is equipped with a carcass having arranged therein two layers of ply comprising a nylon cord covered with a rubber, and has the structure shown in Fig. 1.

[0028]

[Viscoelasticity test]

Loss tangent tan δ and dynamic complex modulus E* were measured under the following measurement conditions.

Measuring apparatus: Viscoelasticity measuring apparatus Eplexer 1500N, manufactured by GABO

Measurement conditions:

Compression mode

-60°C to 20°C: static strain 3.0%, dynamic strain 0.1%

20°C to 60°C: static strain 3.0%, dynamic strain 1.0%

Shape of test piece: 5 mm (diameter) × 6 mm

Frequency: 10 Hz

[0029]

[WET brake test and DRY brake test]

A tire having each specification of Examples 1 to 8 and Comparative Examples 1 to 4 was set in a normal rim, and mounted to the commercially available small-sized motorcycle of 110 cc displacement in the state that the tire is filled with air so as to be a normal inner pressure (hereinafter referred to as a test vehicle).

Using the test vehicle, a running test on a road surface after adjustment was conducted, and at the time of rapid braking from a given speed, an evaluation point (5-point scale) was determined based on generation G in a range that lock of wheels is not generated. In WET brake test, the test vehicle ran on a road surface adjusted to wet road and an evaluation point of WET brake performance was determined, and in DRY brake test, the test vehicle ran on a dry road surface and an evaluation point of DRY brake performance was determined.

[0030]

[High speed turning test]

Steady circularly turning test that the test vehicle circularly runs at 100 km/h was conducted, and an evaluation point (5-point scale) was determined by functional evaluation by a test driver.

[0031]

[RRC index measurement]

The tire having the above specification was mounted to a 1.7 m drum resistance testing machine, and rolling resistance coefficient (RRC) when running at 60 km/h was obtained, and was indicated in a form of a score. Scores of Examples 1 to 8 and Comparative Examples 2 to 4 shown in Table 1 are relative values when the score of Comparative Example 1 is 100.

[0032]

[Target value]

Target value was set in each score shown in Table 1. Specifically, target values were set such that the score of WET brake test is 3.00 or more, the score of DRY brake test is 3.50 or more, the score of high speed turning test is 3.25 or more, and the score of RRC index is 85 or less.

[0033]

[Correlation between physical properties of material and tire performance]

The correlation between physical properties of material (RRC physical property index, DRY physical property index, WET physical property index, and high speed turning performance physical property index) and score of tire performance (RRC index, DRY braking performance, WET braking performance and high speed turning performance) is shown in the diagrams of Figs. 2 to 5. A plotted on each diagram of Figs. 2 to 5 is a value of Comparative Example 1, B is a value of Comparative Example 2, C is a value of Comparative Example 3, D is a value of Comparative Example 4, E is a value of Example 1, F is a value of Example 2, G is a value of Example 3, H is a value of Example 4, I is a value of Example 5, J is a value of Example 6, K is a value of Example 7, and L is a value of Example 8.

[0034]

Fig. 2 is a diagram showing the correlation between WET physical property index ($10^4 \times \tan\delta$ (-30°C)/E* (-30°C)) and the score of WET braking performance. As shown in Fig. 2, WET physical property index and WET braking performance show very strong correlation. The target value 3.00 is obtained in all of plots of Comparative Examples 1 to 4 and Examples 1 to 8. Because the value of Example 2 (plot F) can be considered as a boundary value, it has been clarified that 3.00 or more that is the target value of WET braking performance is satisfied if WET physical property index is at least 1.4 [MPa^{-1}] or more.

Furthermore, the score of WET braking performance is 3.25 or more as Example 6 (plot J) being a boundary. It has been clarified from this result that in the case that WET physical property index is 2.2 [MPa^{-1}] or more, further excellent WET braking performance (score 3.25 or more) is obtained. Furthermore, from that Example 6 (plot J) is a boundary value, it can say that in the case that the value of E* (-30°C) is 1140 [MPs] or less and the value of tan δ (-30°C) is 0.251 or more, WET braking performance is further excellent.

[0035]

Fig. 3 is a diagram showing the correlation between DRY physical property index (E* (30°C)) and the score of DRY braking performance. As shown in Fig. 3, DRY physical property index and DRY braking performance show very strong correlation. According to the plots of Comparative Examples 1 to 4 and Examples 1 to 8, Example 1 (plot E) is a boundary value of the range in which the target value 3.50 is obtained. It was clarified from this fact that 3.50 or more that is the target value of DRY braking performance is satisfied in the case that DRY physical property value is 9.6 [MPa] or more.

Furthermore, the score of DRY braking performance is

3.75 or more as Example 2 (plot F) being a boundary. It has been clarified from this result that in the case that DRY physical property index is 10.1 [MPa] or more, further excellent DRY braking performance (score 3.75 or more) is obtained.

[0036]

Fig. 4 is a diagram showing the correlation between high speed turning performance physical property index (E* (60°C)) and the score of high speed turning performance. The present inventors have found that E* (60°C) that has not conventionally been noted in a tire composition has important correlation with turning performance of a tire as shown in Fig. 4. The target value being 3.25 is obtained in all of Comparative Examples 1 to 4 and Examples 1 to 8 in Fig. 4. The value of Comparative Example 3 (plot C) can be considered as a boundary value. Therefore, it has been clarified that if high speed turning performance physical property index is at least 6.9 [MPa] or more, 3.25 or more that is the target value of high speed turning performance is satisfied.

Furthermore, the score of high speed turning performance is 3.50 or more as Example 3 (plot G) being a boundary. It has been clarified from this result that in the case that E* (60°C) is 7.4 [MPa] or more, further excellent high speed turning performance (score 3.50 or more) is obtained.

[0037]

Fig. 5 is a diagram showing the correlation between RRC physical property index (tan δ (60°C)) and the score of RRC index. As shown in Fig. 5, tan δ (60°C) shows strong correlation with RRC index, and is important for low fuel consumption. An approximate curve of R^2=0.9679 was obtained from the plots of Comparative Examples 1 to 4 and Examples 1 to 8 in Fig. 5. It has been clarified from the approximate curve that in the case that tan δ (60°C) is 0.182 or less, 85 or less that is the target value of RRC index can be achieved.

Furthermore, it has been clarified from the above approximate curve that in the case that tan δ (60°C) is 0.155 or less, further excellent RRC index (80 or less) can be achieved.

Still further, it is recognized in Fig. 5 that plots C to K constitutes two clusters, and the boundary of those two clusters is tan δ (60°C)=0.128. δ (60°C)=0.128 nearly corresponds to the case of RRC index 75. The cluster belonging to tan δ (60°C)≤0.128 is that RRC index is particularly low, and lower fuel consumption can be realized. It is apparent from the consideration that in the case that tan δ (60°C) is 0.128 or less, further excellent RRC index (75 or less) can be achieved.

[0038]

Summarizing the above results, the tire composition satisfying all of the following requirements shows excellent characteristics in each of low fuel consumption, braking performance and turning performance.

WET physical property index is 1.4 [MPa^{-1}] or more.

DRY physical property index (E* (30°C)) is 9.6 [MPa] or more.

RRC physical property index (tan δ (60°C)) is 0.182 or less.

High speed turning performance physical property index (E* (60°C)) is 6.9 [MPa] or more.

[0039]

Furthermore, the tire composition satisfying all of the following requirements shows further excellent characteristics in each of low fuel consumption, braking performance and turning performance.

WET physical property index is 2.2 [MPa^{-1}] or more.

DRY physical property index (E* (30°C)) is 10.1 [MPa] or more.

RRC physical property index (tan δ (60°C)) is 0.155 or less.

High speed turning performance physical property index (E* (60°C)) is 7.4 [MPa] or more.

Compositions of Comparative Examples 1 to 4 and

Examples 1 to 8 and test results are described below.

[0040]

[Comparative Example 1]

The tire composition of Comparative Example 1 contains E-SBR (emulsion polymerized styrene-butadiene rubber) (137.5 parts by weight). Breakdown of E-SBR is an oil component (37.5 parts by weight) and a polymer component (100 parts by weight). The tire composition of Comparative Example 1 has a composition comprising a mixture of carbon black (100 parts by weight) and the above E-SBR. The tire composition further contains zinc oxide (3 parts by weight), stearic acid (1 part by weight), an aroma oil (32.5 parts by weight), two kinds of anti-aging agents (3.5 parts by weight and 2 parts by weight), microcrystalline wax (2 parts by weight), sulfur (2 parts by weight), and a vulcanization accelerator (1.5 parts by weight). Each content is a value based on the polymer part (a polymer component in E-SBR) (100 parts by weight).

[0041]

As shown in Table 1, the tire composition of Comparative Example 1 is that RRC index is remarkably high as compared with other examples (Comparative Examples 2 to 5 and Examples 1 to 8) and does not reach the target value. Comparative Example 1 is a typical example of the conventional tire composition, and the desired characteristics were not obtained in low fuel consumption.

[0042]

[Comparative Example 2]

The tire composition of Comparative Example 2 has a composition comprising a mixture of E-SBR (137.5 parts by weight) and carbon black (75 parts by weight), similar to Comparative Example 1. The tire composition further contains zinc oxide (3 parts by weight), stearic acid (1 part by weight), an aroma oil (8 parts by weight), two kinds of anti-aging agents (3.5 parts by weight and 2 parts by weight), microcrystalline wax (2 parts by weight), sulfur (1.7 parts by weight), and a vulcanization accelerator (0.7 parts by weight). Each content is a value based on the polymer part (a polymer component in E-SBR) (100 parts by weight).

[0043]

As shown in Table 1, the tire composition of Comparative Example 2 is that RRC index does not reach the target value. Comparative Example 2 is an example of a composition close to the conventional general tire composition, and the desired characteristics were not obtained in low fuel consumption.

[0044]

[Comparative Example 3]

The tire composition of Comparative Example 3 contains E-SBR that is a different kind from Comparative Examples 1 and 2 (100 parts by weight), carbon black (50 parts by weight), zinc oxide (3 parts by weight), stearic acid (1 part by weight), an aroma oil (15 parts by weight), two kinds of anti-aging agents (3.5 parts by weight and 2 parts by weight), microcrystalline wax (2 parts by weight), sulfur (1.7 parts by weight), and a vulcanization accelerator (0.7 parts by weight). Each content is a value based on the polymer part (100 parts by weight).

[0045]

As shown in Table 1, the tire composition of Comparative Example 3 showed improvement in RRC index, but DRY braking performance does not reach the target value.

[0046]

[Comparative Example 4]

The tire composition of Comparative Example 4 has a composition comprising a mixture of a polymer part (100 parts by weight) comprising natural rubber (70 parts by weight) and S-SBR (solution polymerized styrene-butadiene rubber) (30 parts by weight), and carbon black (50 parts by weight). The S-SBR is a non-oil-extended styrene-butadiene rubber, and is an end-modified polymer for silica formulation. The tire composition further contains zinc oxide (3 parts by weight), stearic acid (1 part by weight), two kinds of anti-aging agents (3.5 parts by weight and 2 parts by weight), microcrystalline wax (2 parts by weight), sulfur (1.7 parts by weight), and a vulcanization accelerator (0.7 parts by weight). Each content is a value based on the polymer part (100 parts by weight).

[0047]

As shown in Table 1, the tire composition of Comparative Example 4 showed improvement in RRC index, but DRY braking performance does not reach the target value.

[0048]

[Example 1]

The tire composition of Example 1 has a composition comprising a mixture of a polymer part (100 parts by weight) comprising natural rubber (60 parts by weight) and S-SBR (40 parts by weight), and carbon black (50 parts by weight). The tire composition further contains zinc oxide (3 parts by weight), stearic acid (1 part by weight), two kinds of anti-aging agents (3.5 parts by weight and 2 parts by weight), microcrystalline wax (2 parts by weight), sulfur (1.7 parts by weight), and a vulcanization accelerator (0.7 parts by weight). Each content is a value based on the polymer part (100 parts by weight).

[0049]

As shown in Table 1, the tire composition of Example 1 shows good RRC index, and reaches the target values in DRY braking performance, WET braking performance and high speed turning performance. The tire composition of Example 1 has a composition similar to Comparative Example 4, but is satisfied in preferred performances in all of items. Furthermore, the tire composition of Example 1 uses natural rubber, and therefore has the advantage that availability of a polymer is excellent. Similarly, it says that availability of a polymer is excellent in Examples 2 to 6 described hereinafter.

[0050]

[Example 2]

The tire composition of Example 2 has a composition comprising a mixture of a polymer part (100 parts by weight) comprising natural rubber (60 parts by weight) and S-SBR (40 parts by weight), and carbon black (50 parts by weight). The tire composition further contains zinc oxide (3 parts by weight), stearic acid (1 part by weight), two kinds of anti-aging agents (3.5 parts by weight and 2 parts by weight), microcrystalline wax (2 parts by weight), sulfur (1.7 parts by weight), and a vulcanization accelerator (1.7 parts by weight). Each content is a value based on the polymer part (100 parts by weight).

[0051]

As shown in Table 1, the tire composition of Example 2 satisfies the target value in each of RRC index, DRY braking performance, WET braking performance and high speed turning performance. Particularly, DRY braking performance is remarkably excellent as compared with other Examples.

[0052]

[Example 3]

The tire composition of Example 3 has a composition comprising a mixture of a polymer part (100 parts by weight) comprising natural rubber (35 parts by weight), S-SBR (50 parts by weight) and BR (butadiene rubber) (15 parts by weight), and carbon black (50 parts by weight). The tire composition further contains zinc oxide (3 parts by weight), stearic acid (1 part by weight), two kinds of anti-aging agents (3.5 parts by weight and 2 parts by weight), microcrystalline wax (2 parts by weight), sulfur (1.7 parts by weight), and a vulcanization accelerator (0.7 parts by weight). Each content is a value based on the polymer part (100 parts by weight).

[0053]

As shown in Table 1, the tire composition of Example 3 satisfies the target value in each of RRC index, DRY braking performance, WET braking performance and high speed turning performance.

[0054]

[Example 4]

The tire composition of Example 4 has a composition comprising a mixture of a polymer part (100 parts by weight) comprising natural rubber (50 parts by weight), S-SBR (35 parts by weight) and BR (15 parts by weight), and carbon black (50 parts by weight). The tire composition further contains zinc oxide (3 parts by weight), stearic acid (1 part by weight), two kinds of anti-aging agents (3.5 parts by weight and 2 parts by weight), microcrystalline wax (2 parts by weight), sulfur (1.7 parts by weight), and a vulcanization accelerator (1.7 parts by weight). Each content is a value based on the polymer part (100 parts by weight).

[0055]

As shown in Table 1, the tire composition of Example 4 satisfies the target value in each of RRC index, DRY braking performance, WET braking performance and high speed turning performance, and can achieve lower fuel consumption as compared with Examples 1 to 3.

[0056]

[Example 5]

The tire composition of Example 5 has a composition comprising a mixture of a polymer part (100 parts by weight) comprising natural rubber (35 parts by weight), S-SBR (50 parts by weight) and BR (15 parts by weight), and carbon black (50 parts by weight). The tire composition further contains zinc oxide (3 parts by weight), stearic acid (1 part by weight), two kinds of anti-aging agents

(3.5 parts by weight and 2 parts by weight), microcrystalline wax (2 parts by weight), sulfur (1.7 parts by weight), and a vulcanization accelerator (1.7 parts by weight). Each content is a value based on the polymer part (100 parts by weight).

[0057]

As shown in Table 1, the tire composition of Example 5 satisfies the target value in each of RRC index, DRY braking performance, WET braking performance and high speed turning performance.

[0058]

[Example 6]

The tire composition of Example 6 has a composition comprising a mixture of a polymer part (100 parts by weight) comprising natural rubber (70 parts by weight) and S-SBR (30 parts by weight), and carbon black (50 parts by weight). The tire composition further contains zinc oxide (3 parts by weight), stearic acid (1 part by weight), two kinds of anti-aging agents (3.5 parts by weight and 2 parts by weight), microcrystalline wax (2 parts by weight), sulfur (2.3 parts by weight), and a vulcanization accelerator (1.7 parts by weight). Each content is a value based on the polymer part (100 parts by weight).

[0059]

As shown in Table 1, the tire composition of Example

6 satisfies the target value in each of RRC index, DRY braking performance, WET braking performance and high speed turning performance. The tire composition of Example 6 realizes the same RRC index as in Examples 1 to 5, and additionally has remarkably excellent high speed turning performance as compared with each Example. Furthermore, the tire composition of Example 6 uses natural rubber in an amount larger than that of Example 1, thereby suppressing the amount of S-SBR used. Therefore, availability of a polymer is further excellent.

[0060]

[Example 7]

The tire composition of Example 7 contains a polymer part (100 parts by weight) comprising a mixture of S-SBR (85 parts by weight) different from Comparative Example 4 and Examples 1 to 6, and BR (15 parts by weight). The S-SBR is a non-oil-extended styrene-butadiene rubber, and is an end-modified polymer for silica formulation. Furthermore, the tire composition has a composition comprising a mixture of the polymer part (100 parts by weight), silica (60 parts by weight) and a silane coupling agent (4.8 parts by weight). The tire composition further contains zinc oxide (3 parts by weight), stearic acid (1 part by weight), two kinds of anti-aging agents (3.5 parts by weight and 2 parts by weight), microcrystalline wax (2 parts by weight), sulfur (1.7 parts by weight), and two kinds of vulcanization accelerators (2.2 parts by weight and 0.75 parts by weight). The tire composition further contains fatty acid zinc salt (3 parts by weight). Each content is a value based on the polymer part (100 parts by weight).

[0061]

As shown in Table 1, the tire composition of Example 7 shows remarkably low RRC index as compared with other Examples, and realizes excellent low fuel consumption performance. Furthermore, the tire composition satisfies the target value in each of DRY braking performance, WET braking performance and high speed turning performance.

It can consider that in the tire composition of Example 7, by using surface-treated silica and end-modified S-SBR for silica, interaction between silica and a polymer is enhanced, RRC physical property index (tan δ (60°C)) is particularly low, and excellent low fuel consumption is realized.

[0062]

[Example 8]

The tire composition of Example 8 has a composition comprising a mixture of a polymer part (100 parts by weight) comprising natural rubber (20 parts by weight), the same S-SBR (65 parts by weight) as in Example 7 and BR (15 parts by weight), and silica (80 parts by weight). Silane coupling agent (6.4 parts by weight) and a naphthene oil (20 parts by weight) are further added. The tire composition further contains zinc oxide (3 parts by weight), stearic acid (1 part by weight), two kinds of anti-aging agents (3.5 parts by weight and 2 parts by weight), microcrystalline wax (2 parts by weight), sulfur (1.7 parts by weight), and two kinds of vulcanization accelerators (2.2 parts by weight and 0.75 parts by weight). The tire composition further contains fatty acid zinc salt (3 parts by weight). Each content is a value based on the polymer part (100 parts by weight).

[0063]

As shown in Table 1, the tire composition of Example 8 satisfies the target value in each of RRC index, DRY braking performance, WET braking performance and high speed turning performance. It is considered that similar to Example 7, by using surface-treated silica and S-SBR that is an end-modified polymer for silica, tan δ (60°C) is decreased. Furthermore, the tire composition of Example 8 uses natural rubber in an amount larger than that of Example 7, thereby decreasing the amount of S-SBR used. Therefore, availability of a polymer can be improved.

[0064]

Examples 1 to 8 satisfy the target value in each of

RRC index, DRY braking performance, WET braking performance and high speed turning performance, and additionally are that the value of E* (30°C) affecting DRY braking performance is 11.2 [MPa] or more. It say from this fact that the value of E* (30°C) is preferably 11.2 [MPa] or more in order to satisfy the above each performance and additionally to exhibit further excellent DRY braking performance.

[Industrial Applicability]

[0065]

The tire composition according to the present invention can be used as a tire for motorcycle, and the tire can be mounted to various motorcycles. Particularly, the tire is suitable for use in a small-sized motorcycle having mounted thereto a motor of small displacement.

[Description of Reference Numerals and Signs]

[0066]

1	Tire
3	Bead part
4	Side wall part
5	Tread part
6	Shoulder part
8	Carcass
9	Center area
S	Grounding part

CL Equatorial plane of tire