DESCRIPTION

MEMBER EXCELLENT IN DAMPING CAPACITY, PROCESS FOR PRODUCING THE SAME, AND STEEL SHEET EMPLOYED AS MEMBER EXCELLENT IN DAMPING CAPACITY

Technical Field

The present invention relates to a member excellent in damping capacity that are used for home appliances and parts for cars, such as oil pans, which have problems of noise and vibration at the time of use and are required to have high noise-reducing properties and vibration-damping properties, a process for producing the same, and a steel sheet suitable for the member excellent in damping capacity.

Background Art

Low-noise members and low-vibration members have been increasingly demanded with the social needs for reducing noise and vibration of, for example, parts for cars, such as oil pans, and home appliances. For example, regarding so-called low-noise members, such as oil pans for cars, which are required to be low in noise, Patent Document 1 describes the use of, for example, a resin composite type damping metal sheet having a viscoelastic resin between two metal sheets. However, such a resin composite type damping metal sheet is high in manufacturing cost and low in workability

and weldability, and the member itself is therefore demanded to have excellent low-noise performance or high vibration-damping performance. In order to reduce noise or vibration of the member itself, in general, the thickness of the sheet is increased for enhancing the sound isolation, or the rigidity is increased. This leads to an increase in material cost or an increase in the member weight.

Accordingly, it is desired to employ a steel sheet, which is less expensive than the resin composite type damping metal sheet or the like, as a member material and to enhance vibration damping of the steel sheet itself constituting a member, that is, to enhance the damping capacity of a member by constituting the member with a steel sheet that is excellent in damping capacity. As the steel sheet having excellent damping capacity, Patent Documents 2 to 4 propose ferromagnetic-type damping steel sheets utilizing hysteresis of domain wall movement, for example, high-alloy steel sheets containing 1% or more of at least one ferrite former such as Al, Si, or Cr. These steel sheets perform vibration damping and noise reduction by dissipating vibration energy by converting it into domain wall movement energy.

Patent Document 1: Japanese Unexamined Patent Application Publication No. 10-86271

Patent Document 2: Japanese Unexamined Patent

Application Publication No. 4-99148

Patent Document 3: Japanese Unexamined Patent Application Publication No. 52-73118

Patent Document 4: Japanese Unexamined Patent Application Publication No. 2002-294408

Disclosure of Invention

The high-alloy steel sheets described in Patent Documents 2 to 4 are hard and are poor in workability and are therefore unsuitable as members for, for example, oil pans produced by deep drawing fabrication.

The present invention has been accomplished under these circumstances, and it is an object thereof to provide a member that employs a steel sheet having good workability and is excellent in damping capacity for enhancing low-noise properties and vibration-damping properties, a process for producing such a member, and a steel sheet suitable for the member excellent in the damping capacity.

The present inventors have conducted intensive studies on damping performance such as noise performance of fabricated steel sheets and, as a result, have found the fact that a fabricated steel sheet can exhibit excellent damping performance by having an average grain diameter of 30 μm or more and a Vickers hardness of 120 or less at the hardest part after the fabrication.

The present invention has been accomplished based on these findings and relates to:

(1) a member excellent in damping capacity, being produced by fabricating a steel sheet having an average grain diameter of 30 μm or more and a Vickers hardness of 120 or less at the hardest part thereof.

(2) A steel sheet having an average grain diameter of 50 μm or more can exhibit more excellent damping performance. Regarding the steel sheet, for example,

(3) a steel sheet having a composition composed of, by mass%, C: at most 0.050%, Si: less than 1.0%, Mn: 0.05 to 0.5%, P: at most 0.04%, S: at most 0.03%, Al: at most 1.0%, N: at most 0.005%, and the balance: Fe and inevitable impurities is preferably used.

(4) It is preferable that the steel sheet of the above (3) further contain, by mass%, B: 0.0001 to 0.0030%.

Furthermore, it is preferable to use

(5) a steel sheet having a composition composed of, by mass%, C: at most 0.005%, Si: less than 1.0%, Mn: 0.05 to 0.5%, P: at most 0.04%, S: at most 0.03%, Al: at most 1.0%, N: at most 0.005%, Ti: 0.01 to 0.06%, B: 0.0001 to 0.0030%, and the balance: Fe and inevitable impurities, or

(6) a steel sheet having a composition composed of, by mass%, C: at most 0.005%, Si: less than 1.0%, Mn: 0.05 to 0.5%, P: at most 0.04%, S: at most 0.03%, Al: at most 0.004%, N: at

most 0.005%, and the balance: Fe and inevitable impurities.

In the above-mentioned steel sheets, the crystal grain diameter can be adjusted to 30 μm or more by heat treatment after the fabrication into a desired shape, but it is preferred that the average grain diameter of the steel sheet before the fabrication into a desired shape be adjusted to 30 μm or more, more preferably to 50 μm or more, in advance, and that the steel sheet be employed as a member excellent in damping capacity by being fabricated into a desired shape and then being heat-treated in a temperature range of 500°C or higher.

That is, the steel sheet is

(7) a steel sheet having a composition composed of, by mass%, C: at most 0.050%, Si: less than 1.0%, Mn: 0.05 to 0.5%, P: at most 0.04%, S: at most 0.03%, Al: at most 1.0%, N: at most 0.005%, and the balance: Fe and inevitable impurities and having an average grain diameter of 30 μm or more, wherein the steel sheet is employed as a member excellent in damping capacity by being fabricated into a desired shape and then being heat-treated in a temperature range of 500°C or higher;

(8) a steel sheet further containing, by mass%, B: 0.0001 to 0.0030%, in addition to the composition of the steel sheet in the above (7); or

(9) a steel sheet having a composition composed of, by mass%,

C: at most 0.005%, Si: less than 1.0%, Mn: 0.05 to 0.5%, P: at most 0.04%, S: at most 0.03%, Al: at most 1.0%, N: at most 0.005%, Ti: 0.01 to 0.06%, B: 0.0001 to 0.0030%, and the balance: Fe and inevitable impurities and having an average grain diameter of 30 μm or more, wherein the steel sheet is employed as a member excellent in damping capacity by being fabricated into a desired shape and then being heat-treated in a temperature range of 500°C or higher.

In the steel sheets described in (7) to (9) above, (10) an average grain diameter of 50 μm or more is further preferred.

The member excellent in the damping capacity of the present invention can be produced by, for example, (11) fabricating any of the steel sheets in the above-mentioned (7) to (10) into a desired shape and then heat-treating it in a temperature range of 500°C or more.

In the steel sheet having the element composition described in the above (7), when the C and Al contents are reduced for ensuring excellent crystal grain growth characteristics, an average grain diameter of 30 μm or more can be readily ensured by performing the heat treatment after the fabrication at 600°C or higher. That is, when the heat treatment after the fabrication is performed at 600°C or higher, a steel sheet shown in the following (12) is preferred.

(12) A steel sheet having a composition composed of, by mass%, C: at most 0.005%, Si: less than 1.0%, Mn: 0.05 to 0.5%, P: at most 0.04%, S: at most 0.03%, Al: at most 0.004%, N: at most 0.005%, and the balance: Fe and inevitable impurities, wherein the steel sheet is employed as a member excellent in damping capacity by being fabricated into a desired shape and then being heat-treated in a temperature range of 600°C or higher.

The member excellent in the damping capacity of the present invention can be produced by, for example,
(13) fabricating the steel sheet in the above (12) into a desired shape and then heat-treating it in a temperature range of 600°C or higher.

The present invention has made it possible to provide a member excellent in damping capacity (hereinafter, referred to as highly damping member), such as low-noise members suitable for, for example, oil pans. Furthermore, the highly damping member of the present invention can be applied to, in addition to oil pans, members that are strictly fabricated and required to have excellent low-noise performance or vibration-damping performance (damping capacity) in the fields of, for example, cars and home appliances.

Brief Description of Drawings

[Fig. 1] Fig. 1 is a drawing showing a cup-shaped sample applied with a strain gauge.

[Fig. 2] Fig. 2 is a graph showing a relationship between excitation force and maximum strain.

Best Modes for Carrying Out the Invention

The gist of the present invention is that a damping member produced from a steel sheet by, for example, press working is provided with high damping performance, such as excellent low-noise performance, by reducing the number of crystal grain boundaries by adjusting the average grain diameter of the steel sheet fabricated into the member to 30 μm or more, facilitating the domain wall movement in the steel sheet by reducing the residual stress and strain in the crystal grains by adjusting the Vickers hardness at the hardest part to 120 or less, and enhancing the vibration-damping capacity of the steel sheet by converting the vibration energy into domain wall movement energy.

An average grain diameter of smaller than 30 μm leads to a large number of crystal grain boundaries, which inhibits the movement of domain wall. Therefore, excellent damping performance cannot be obtained.

A Vickers hardness of 120 or less at the hardest part leads to an increase in dislocation density in the crystal grains, which inhibits the movement of domain wall.

Therefore, excellent damping performance cannot be obtained.

The steel sheet used in the present invention may be a hot-rolled steel sheet or a cold-rolled steel sheet. For example, hot-rolled steel sheets of JIS G 3131 SPHD or SPHE grade and cold-rolled steel sheets of JIS G 3141 SPCD or SPCE grade, which are conventionally used for members that are required to be strictly fabricated by deep drawing, can be used. In particular, a steel sheet containing, by mass%, C: at most 0.050%, Si: less than 1.0%, Mn: 0.05 to 0.5%, P: at most 0.04%, S: at most 0.03%, Al: at most 1.0%, and N: at most 0.005% is preferred because of the following reasons.

C: since C forms carbides to prevent grain growth, the number of grain boundaries, which inhibit the movement of domain wall, cannot be reduced. Accordingly, the C content is controlled to 0.050 mass% or less. In addition, from the viewpoint of enhancement of workability, the C content is preferably 0.005 mass% or less.

Si: Si enhances solid solubility, but an excessive content of Si prevents manufacturability and workability. Accordingly, the Si content is controlled to less than 1.0 mass%, more preferably 0.5 mass% or less, and further preferably 0.3 mass% or less.

Mn: Mn forms sulfides to improve hot brittle and also enhances solid solubility. Accordingly, the Mn content is preferably controlled to 0.05 mass% or more. However, an

excessive content deteriorates workability or leads to an increase in cost. Accordingly, the upper limit of the Mn content is 0.5 mass%.

P: P enhances solid solubility, but a P content greater than 0.04 mass% leads to deterioration of workability. Accordingly, the upper limit of the P content is 0.04 mass%.

S: an S content greater than 0.03 mass% leads to formation of sulfides, which significantly prevents grain growth. Accordingly, the S content is 0.03 mass% or less, preferably 0.01 mass% or less, more preferably 0.005 mass% or less, and further preferably less than 0.003 mass%.

Al: Al is a deoxidizing element. An excessive content prevents manufacturability and leads to an increase in cost. Accordingly, the Al content is preferably controlled to 1.0 mass% or less. In addition, since Al forms AlN to significantly prevent grain growth, the Al content is further preferably 0.004 mass% or less.

N: when the N content is greater than 0.005 mass%, precipitate is formed to prevent grain growth. Accordingly, the N content is 0.005 mass% or less, preferably 0.003 mass% or less, and a smaller content is preferred.

The balance other than the above-mentioned elements is preferably Fe and inevitable impurities. In addition, in order to improve aging properties by reducing the content of solid-solution N, 0.0001 to 0.0030 mass% of B may be further

contained. In a B content less than 0.0001 mass%, the effect of enhancing aging-resistance properties is insufficient, and a content greater than 0.0030 mass% leads to deterioration of casting properties, resulting in an increase in manufacturing cost. Furthermore, from the viewpoint of enhancing deep drawing properties by fixing C and N as precipitate, 0.01 to 0.06 mass% of Ti may be further contained, while the C content is controlled to 0.005 mass% or less and the contents of Si, Mn, P, S, Al, and N are controlled to the above-mentioned ranges; and from the viewpoint of improving secondary working embrittlement, 0.0001 to 0.0030 mass% of B may be contained. This is because that a Ti content of less than 0.01 mass% leads to softness and insufficient slow-aging properties, and a Ti content of greater than 0.06 mass% leads to an increase in cost. A B content of less than 0.0001 mass% is insufficient for opposing secondary working embrittlement, and a B content of greater than 0.0030 mass% leads to deterioration of casting properties, resulting in an increase in cost.

The highly damping member of the present invention can be produced by fabricating a steel sheet that satisfies the above-described specifications and element compositions into a desired shape and then heat-treating it in a temperature range of 500°C or more. It is thought that the heat treatment at 500°C or more causes growth of grains to

decrease the number of grain boundaries and also reductions in residual stress and strain in crystal grains to facilitate the movement of domain wall.

Furthermore, it is preferable that the average grain diameter of the steel sheet used in the present invention be controlled to 30 μm in advance, that is, before the fabrication into a desired shape. This can ensure an average grain diameter of 30 μm or more after fabrication despite the conditions of heat treatment and is therefore preferred.

When more excellent crystal grain growth characteristics are ensured by reducing the C and Al contents, specifically, to C ≤ 0.005 mass% and Al ≤ 0.004 mass% as described above and heat treatment that is performed after the fabrication into a desired shape is carried out at 600°C or more, an average grain diameter of 30 μm or more or 50 μm or more can be preferably obtained during the heat treatment. That is, it is preferred that a steel sheet having a composition composed of, by mass%, C: at most 0.005%, Si: less than 1.0%, Mn: 0.05 to 0.5%, P: at most 0.04%, S: at most 0.03%, Al: at most 0.004%, N: at most 0.005%, and the balance: Fe and inevitable impurities be fabricated into a desired shape and then heat-treated in a temperature range of 600°C or more to give a highly damping member.

Furthermore, in the above, when the temperature for the heat treatment that is performed after the fabrication into a desired shape is higher than 910°C, the energy cost is significantly increased. Therefore, the heat treatment is desirably performed at 910°C or less. In addition, in the present invention, the heat treatment after the fabrication is also purposed for improving the brittleness. Since excessively coarsened grains may cause a problem of embrittlement, an average grain diameter of 2000 μm or less is preferred.

The process of producing the highly damping member of the present invention is particularly effective for producing a member that is fabricated by deep drawing or bending. Furthermore, from the viewpoint of manufacturing cost, a hot-rolled steel sheet having a thickness of about 1.6 to 6.0 mm is preferred.

An example of the process for producing a hot-rolled steel sheet used in the present invention will be described below. However, the process for producing the hot-rolled steel sheet is not limited to this example. That is, the hot-rolled steel sheet used in the present invention is produced by heating steel having the above-mentioned elements at a heating temperature less than 1200°C and performing hot-rolling at a finishing temperature of 700°C or more, winding at a winding temperature of 560°C or more,

and scale removing by, for example, pickling. A heating temperature of less than 1000°C is difficult to ensure a finishing temperature higher than 700°C. When a heating temperature is 1200°C or higher, solid-soluted trace impurities precipitate finely during the winding, resulting in prevention of grain growth during the heat treatment. Therefore, the heating temperature is preferably 1000°C or higher and lower than 1200°C and more preferably 1000°C or higher and lower than 1150°C. A finishing temperature of lower than 700°C is prone to deteriorate a plate-like shape, and the finishing temperature is therefore controlled to 700°C or higher. A winding temperature of lower than 560°C is prone to generate fine precipitate, such as AlN, during the heat treatment that is performed after fabrication to prevent grain growth, and the winding temperature is therefore controlled to 560°C or higher.

Furthermore, the hot-rolled steel sheet after the winding or the scale removing is preferably annealed at about 650 to 900°C for enhancing the growth of crystals of the hot-rolled steel sheet to give an average grain diameter of 30 μm or more or 50 μm or more. An annealing temperature of lower than 650°C in the annealing above is insufficient for growth of grains. In a temperature higher than 900°C, the effect tends to be saturated, resulting in merely an increase in cost. The average grain diameter of the hot-

rolled sheet can be readily adjusted to a desired level by controlling the annealing temperature in the annealing. After the annealing, scale is preferably removed by, for example, pickling. However, the pickling after the annealing can be omitted when the annealing is performed to a hot-rolled steel sheet after scale removing in a non-acidic atmosphere adjusted such that the scale will not be generated.

In addition, in the case that the hot rolling is unsuitable, for example, in the cases that a steel sheet has a thickness of less than 1.6 mm or the surface is particularly required to be fine, a cold-rolled steel sheet is preferably used though the manufacturing cost is increased. The cold-rolled steel sheet used in the present invention is not particularly limited and can be produced by using a hot-rolled steel sheet including the above-mentioned elements and produced by the above-described process as a base material, cold rolling the base material at a rolling ratio of 80% or less, and annealing it at an annealing temperature of 800°C or more. A cold-rolling ratio of greater than 80% or an annealing temperature of lower than 800°C may generate a fine grain structure after the annealing and make it difficult to give a grain diameter of 30 μm or more after the heat treatment that is performed after fabrication. Accordingly, the cold-rolling ratio is

adjusted to 80% or less, and the annealing temperature is adjusted to **800°C or lower**. The cold-rolling ratio may be properly adjusted within the range of 80% or less depending on a desired thickness. An annealing temperature higher than 900°C is prone to be associated with a difficulty in manufacturing and significantly increased manufacturing cost. Therefore, the annealing temperature is preferably 900°C or less.

The highly damping member of the present invention can be produced only by heat-treating a fabricated steel sheet and can be therefore welded with another member or applied to coating or printing without any problems.

Examples

Example 1

A steel slab including elements within the range of the present invention shown in Table 1 was subjected to re-heating at a heating temperature of 1100°C, hot rolling at a finishing temperature of 930°C, winding at a winding temperature of 600°C, and pickling to produce a hot-rolled steel sheet having a thickness of 3.6 mm and a quality equivalent to SPHE. Furthermore, a part of the resulting hot-rolled steel sheet was subjected to hot-rolled sheet annealing at 700°C for one hour. The hot-rolled steel sheet not applied with the hot-rolled sheet annealing and the

steel sheet applied with the hot-rolled sheet annealing were observed for structures of the cross-sections in the rolling direction of the steel sheets, and average grain diameters were determined by an intercept method described in JIS G 0551. The average grain diameter of the steel sheet not applied with the hot-rolled sheet annealing was 25 μm, and the average grain diameter of the steel sheet applied with the hot-rolled sheet annealing was 43 μm.

In order to simulate conditions for fabrication as a highly damping member (in this Example, a low-noise member), disks of 66 mmφ were punched out from the steel sheet not applied with the hot-rolled sheet annealing and the steel sheet applied with the hot-rolled sheet annealing and were subjected to drawing fabrication with a flat-bottom punch of 33 mmφ (drawing ratio: 2) to produce cup-shaped samples, Nos. 1 to 9. The cup-shaped samples, Nos. 1 to 9, were heat-treated under conditions shown in Table 2. The cup-shaped samples were struck with an impact hummer (manufactured by PCB PIEZOTRONICS, Inc., model No.: 086B01) at an excitation force within a range of 2.0 to 2.5 Nrms according to a method of JIS A 1409, and each reverberation time T_{60} was measured. The loss factor η was determined based on a damping rate method by the following equation:

$H = 2.2/(T_{60} \cdot f_0)$.

Here, f_0 denotes the natural frequency of the cup-shaped

sample and is 3.5 kHz.

Furthermore, the cup-shaped samples were cut out plane-symmetrically in the cup height direction (in the direction of drawing) after the measurement of the reverberation time. The cut-out face of each one-half of the samples symmetrically cut out in the cup height direction was observed for the structure, and Vickers hardness was measured at a test force of 4.9 N (500 g) in the cup edge direction at a pitch of 10 mm from the top of the cup. The Vickers hardness at the hardest point among the measured points (5 points) was defined as the Vickers hardness at the hardest part of the cup-shaped sample. Average of grain diameters of the observed five points was determined and was defined as the average grain diameter of the cup-shaped samples.

Table 2 shows the results. The samples, Nos. 4, 5, 8, and 9, which were heat-treated by the method of the present invention each had an average grain diameter of 30 μm or more and a Vickers hardness of 120 or less and exhibited high damping capacity, such as a loss factor η of 0.001 or more, and were confirmed to be excellent in low-noise performance. In particular, samples, Nos. 5 and 9, which each had an average grain diameter of 50 μm or more, were provided with higher loss factors η, it was confirmed that low-noise performance was enhanced by more excellent damping

capacity.

Table 1

(mass%)

C	Si	Mn	P	S	Al	N
0.003	0.1	0.13	0.01	0.005	0.002	0.0031

Table 2

Sample No.	Hot-rolled sheet annealing	Heat treatment		Average grain diameter (μm)	Vickers hardness	Loss factor η	Notes
		Temp. (°C)	Time (hr)				
1	no	none		25	258	<0.001	Comparative Example
2	no	450	1	25	197	<0.001	Comparative Example
3	no	450	20	28	117	<0.001	Comparative Example
4	no	600	1	31	106	0.005	Inventive Example
5	no	800	1	81	83	0.022	Inventive Example
6	yes	none		43	224	<0.001	Comparative Example
7	yes	450	1	43	197	<0.001	Comparative Example
8	yes	600	1	44	102	0.007	Inventive Example
9	yes	800	1	87	85	0.024	Inventive Example

Example 2

Steel slabs including chemical elements shown in Table 3 were subjected to re-heating at a heating temperature of 1100°C, hot rolling at a finishing temperature of 910°C, winding at a winding temperature of 700°C, and pickling to produce hot-rolled steel sheets having a thickness of 3.2 mm. Furthermore, a part of each resulting hot-rolled steel sheet was subjected to hot-rolled sheet annealing at 800°C for 2

hours. As in Example 1, the hot-rolled steel sheets were fabricated into cup-shaped samples. The samples not applied with hot-rolled sheet annealing were heat-treated at 850°C for three hours, and the samples applied with hot-rolled sheet annealing were heat-treated at 500°C for three hours. Thus, samples, Nos. 10 to 17, were produced and measured for average grain diameter, Vickers hardness, and loss factor η. In addition, the hot-rolled steel sheets before the fabrication were measured for average grain diameter, as in Example 1.

Table 3 shows the results. It was confirmed that the samples, Nos. 10 to 15 and Nos. 18 to 21, which were Examples of the present invention, were provided with high loss factors η, achieving low-noise performance by excellent damping capacity. On the other hand, in the samples, Nos. 16 and 17, which contained 5.6% of Al for enhancing vibration-damping performance, the hot-rolled steel sheets themselves as the base materials were extended only by 30% and 31%, respectively, and were broken when fabricated into the cup shape. Thus, the cup-shaped samples could not be fabricated.

Table 3

Sample No.	Chemical element (mass%)									Hot-rolled sheet annealing	Average grain diameter before fabrication (μm)	Heat treatment temp. after fabrication (°C)	Average grain diameter after fabrication and heat treatment (μm)	Vickers hardness	Loss factor η	Notes
	C	Si	Mn	P	S	Al	N	Ti	B							
10	0.003	0.1	0.13	0.01	0.005	0.002	0.0031	-	-	no	28	850	91	87	0.025	Inventive Example
11										yes	87	500	88	95	0.021	Inventive Example
12	0.049	0.1	0.15	0.01	0.008	0.031	0.0025	-	-	no	12	850	38	104	0.006	Inventive Example
13										yes	31	500	31	118	0.002	Inventive Example
14	0.003	0.02	0.15	0.01	0.008	0.033	0.0033	0.035	0.0005	no	23	850	74	80	0.022	Inventive Example
15										yes	43	500	43	98	0.011	Inventive Example
16	0.051	0.3	0.11	0.01	0.011	5.6	0.0029	-	-	no	63	-	-	-	-	Comparative Example
17										yes	72	-	-	-	-	Comparative Example
18	0.042	0.01	0.18	0.01	0.005	0.035	0.0021	-	0.0009	no	15	850	41	105	0.007	Inventive Example
19										yes	39	500	40	101	0.008	Inventive Example
20	0.002	0.01	0.15	0.01	0.007	0.041	0.0023	-	0.0012	no	25	850	77	85	0.021	Inventive Example
21										yes	48	500	48	91	0.013	Inventive Example

Example 3

As shown in Fig. 1, the cup-shaped sample, No. 1, of Comparative Example and the cup-shaped sample, No. 4, of Inventive Example produced in Example 1 were each attached with a strain gauge at the inside of the cup (at a position 5 mm from the edge of the cup). The outside of the cup was struck with an impact hammer (manufactured by PCB PIEZOTRONICS, Inc., model No.: 086B01) to give vibration while varying the excitation force. The maximum strain at each excitation force was measured.

Table 4 and Fig. 2 show the results. The cup-shaped sample, No. 4, as Inventive Example exhibited the maximum strain smaller than that of the cup-shaped sample, No. 1, as Comparative Example, when they were struck with similar excitation forces, and was confirmed to have excellent low-vibration characteristics.

Table 4

Sample No.	Excitation force (Nrms)	Maximum strain ×10-6	Notes
1	0.48	42	Comparative Example
	2.15	103	
4	0.48	33	Inventive Example
	2.01	67	

Example 4

A steel slab including chemical elements shown in Table 5 was subjected to re-heating at a temperature of 1100°C, hot rolling at a finishing temperature of 910°C, winding at a winding temperature of 700°C, and pickling to produce a hot-rolled steel sheet having a thickness of 3.6 mm. The hot-rolled steel sheet was cold-rolled to a thickness of 1.0 mm and then annealed at 700°C or 850°C for one minute, and then 1% temper rolling was performed. The cold-rolled steel sheet was fabricated into cup-shaped samples as in Example 1 and then heat-treated at 500°C for three hours to give samples, Nos. 22 and 23. The samples were measured for average grain diameter, Vickers hardness, and loss factor η. In addition, the cold-rolled steel sheet before the fabrication was also measured for average grain diameter as in Example 1.

Table 5 shows the results. The sample, No. 23, which was Inventive Example, had a high loss factor to give a high damping capacity, but in No. 22 in which the annealing temperature was low and the crystal grain diameter was small, the loss factor was low.

Table 5

Chemical element (mass%)									Hot-rolled sheet annealing (°C)	Average grain diameter before fabrication (μm)	Heat treatment temp. after fabrication (°C)	Average grain diameter after fabrication and heat treatment (μm)	Vickers hardness	Loss factor η	Notes
C	Si	Mn	P	S	Al	N	Ti	B							
0.002	0.02	0.17	0.01	0.008	0.035	0.0021	-	0.0011	700	11	500	11	124	<0.001	Comparative Example
									850	33	500	33	108	0.004	Inventive Example

CLAIMS

1. A member excellent in damping capacity, being produced by fabricating a steel sheet having an average grain diameter of 30 μm or more and a Vickers hardness of 120 or less at the hardest part thereof.

2. The member excellent in damping capacity according to Claim 1, wherein the steel sheet has an average grain diameter of 50 μm or more.

3. The member excellent in damping capacity according to Claim 1 or 2, wherein the steel sheet has a composition comprising, by mass%, 0.050% or less of C, less than 1.0% of Si, 0.05 to 0.5% of Mn, 0.04% or less of P, 0.03% or less of S, 1.0% or less of Al, 0.005% or less of N, and the balance being Fe and inevitable impurities.

4. The member excellent in damping capacity according to Claim 3, wherein the steel sheet further comprises, by mass%, 0.0001 to 0.0030% of B.

5. The member excellent in damping capacity according to Claim 1 or 2, wherein the steel sheet has a composition comprising, by mass%, 0.005% or less of C, less than 1.0% of Si, 0.05 to 0.5% of Mn, 0.04% or less of P, 0.03% or less of

S, 1.0% or less of Al, 0.005% or less of N, 0.01 to 0.06% of Ti, 0.0001 to 0.0030% of B, and the balance being Fe and inevitable impurities.

6. The member excellent in damping capacity according to Claim 1 or 2, wherein the steel sheet has a composition comprising, by mass%, 0.005% or less of C, less than 1.0% of Si, 0.05 to 0.5% of Mn, 0.04% or less of P, 0.03% or less of S, 0.004% or less of Al, 0.005% or less of N, and the balance being Fe and inevitable impurities.

7. A steel sheet having a composition comprising, by mass%, 0.050% or less of C, less than 1.0% of Si, 0.05 to 0.5% of Mn, 0.04% or less of P, 0.03% or less of S, 1.0% or less of Al, 0.005% or less of N, and the balance being Fe and inevitable impurities and having an average grain diameter of 30 μm or more, wherein the steel sheet is employed as a member excellent in damping capacity by being fabricated into a desired shape and then being heat-treated in a temperature range of 500°C or higher.

8. The steel sheet according to Claim 7, further comprising, by mass%, 0.0001 to 0.0030% of B.

9. A steel sheet having a composition comprising, by mass%,

0.005% or less of C, less than 1.0% of Si, 0.05 to 0.5% of Mn, 0.04% or less of P, 0.03% or less of S, 1.0% or less of Al, 0.005% or less of N, 0.01 to 0.06% of Ti, 0.0001 to 0.0030% of B, and the balance being Fe and inevitable impurities and having an average grain diameter of 30 μm or more, wherein the steel sheet is employed as a member excellent in damping capacity by being fabricated into a desired shape and then being heat-treated in a temperature range of 500°C or higher.

10. The steel sheet according to any of Claims 7 to 9, wherein the average grain diameter is 50 μm or more.

11. A process for producing a member excellent in damping capacity, comprising fabricating the steel sheet according to any of Claims 7 to 10 into a desired shape and then heat-treating it in a temperature range of 500°C or more.

12. A steel sheet having a composition comprising, by mass%, 0.005% or less of C, less than 1.0% of Si, 0.05 to 0.5% of Mn, 0.04% or less of P, 0.03% or less of S, 0.004% or less of Al, 0.005% or less of N, and the balance being Fe and inevitable impurities, wherein the steel sheet is employed as a member excellent in damping capacity by being fabricated into a desired shape and then being heat-treated

in a temperature range of 600°C or higher.

13. A process for producing a member excellent in damping capacity, comprising fabricating the steel sheet according to Claim 12 into a desired shape and then heat-treating it in a temperature range of 600°C or higher.