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(54) **Steel strip plated with a zinc-based coating layer containing an inorganic dispersoid.**

(57) A zinc-plated steel strip having enhanced corrosion resistance, workability, and weldability comprising a steel strip substrate, at least one surface coating layer formed on at least a portion of the substrate surface, and, optionally, at least an intermediate coating layer formed between the substrate and the surface coating layer and consisting of zinc or a zinc alloy, the surface coating layer consisting essentially of a zinc or zinc alloy matrix and fine dispersoid particles dispersed in the matrix and consisting an oxide, carbide, nitride, boride, phosphide, or sulfide of Al, Fe, Ti, Mo, Cu, Zn, Ni, Co, La, Ce, or Si.

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Croydon Printing Company Ltd.

STEEL STRIP PLATED WITH A ZINC-BASED COATING LAYER CONTAINING AN INORGANIC DISPERSOID

BACKGROUND OF THE INVENTION

(1) Field of the Invention

The present invention relates to a zinc-plated steel strip with a zinc-based coating layer containing an inorganic dispersoid. More particularly, the present invention relates to a zinc-plated steel strip having at least one zinc-based coating layer containing fine inorganic dispersoid particles and formed on at least one surface of the steel strip, which zinc-plated steel strip exhibits excellent resistance to corrosion, enhanced workability, and superior weldability and is useful for producing cars, building and construction materials, and home electric appliances.

(2) Description of the Related Art

Generally, surface-treated steel strips are required to exhibit a high resistance to corrosion not only before but also after being painted. That is, surface coated steel strips have to exhibit a satisfactory paint adhesion and satisfactory resistances to perforation corrosion and to red rust when the paint film layer is scratched.

Also, surface-treated steel strips must exhibit excellent workability and weldability.

In response to the above-mentioned requirements, various types of plated steel strips having zinc-based coating layers are used, and there have been various attempts to improve plated steel strips having zinc-based coating layers.

Japanese Unexamined Patent Publication (Kokai) No. 56-133,488 published on October 19, 1981, for Nippon Steel Corporation discloses a steel strip plated with two Zn-Fe coating layers. Japanese Examined Patent Publication (Kokoku) No. 50-29821 discloses a steel strip plated with a Zn-Ni coating layer. However, the above-mentioned conventional plated steel strips are not always satisfactory for the above-mentioned strict requirements.

Japanese Examined Patent Publication (Kokoku) Nos. 56-49999 published on November 26, 1981, for Nippon Steel Corporation, 57-17960 published on April 14, 1982, for Nippon Steel Corporation, and 46-37882 published on November 8, 1971 for Nippon Steel Corporation and Japanese Unexamined Patent Publication (Kokai) Nos. 56-123,395 published on September 28, 1981 for Sumitomo Metal Corporation, and 52-109,439 published on September 13, 1977 for Suzuki Motor Corporation, disclose various types of steel strips having at least one plating layer containing inorganic dispersoid and processes of producing the plated steel strips. However, the resultant plated steel strips are not always satisfactory in view of the strict requirements mentioned above.

Under the above-mentioned circumstances, it is strongly desired to provide a new type of plated steel strip which exhibits excellent resistance to corrosion after painting and high resistances to perforation corrosion and powdering after processing.

SUMMARY OF THE INVENTION

An object of the present invention is to provide a zinc-plated steel strip which exhibits excellent resistance to corrosion even after the plated steel strip is painted and the paint film layer is scratched.

Another object of the present invention is to provide a zinc-plated steel strip which exhibits excellent workability and weldability.

The above-mentioned objects can be attained by the zinc-plated steel strip with a zinc-based coating layer of the present invention, which comprises a substrate consisting of a steel strip and at least one surface coating layer plated on at least one portion of at least one surface of the steel strip substrate, the surface coating layer consisting essentially of a matrix consisting of at least one member selected from the group consisting of zinc and zinc alloys and fine dispersoid particles dispersed in the matrix and consisting of at least one member selected from the group consisting of oxides, carbides, nitrides, borides, phosphides, and sulfides of aluminum, iron, titanium, molybdenum, copper, zinc, nickel, cobalt, lanthanum, cerium, and silicon.

The zinc-plated steel strip of the present invention may further comprises an intermediate coating layer formed between the steel strip substrate and the surface coating layer and consisting of at least one member selected from the group consisting of zinc and zinc alloys.

In the surface coating layer, when the matrix consists of zinc, it is preferable that the fine dispersoid particles consist of at least one member selected from the group consisting of oxides, carbides, nitrides, borides, phosphides and surfides of aluminum, iron titanium, molybdenum, copper, zinc, nickel, cobalt, lanthanum, and cerium.

Also, in the surface coating layer, when the matrix consists of a zinc alloy, the fine dispersoid particles consist of at least one member selected from the group consisitng of oxides, carbides, nitrides, borides, phosphides and sulfides of aluminum, iron titanium molybdenum, copper, zinc, nickel, cobalt, lanthanum, cerium, and silicon.

BRIEF DESCRIPTION OF THE DRAWING

Figure 1 is a graph showing the relationship between the content of the specific inorganic dispersoid consisting of silicon dioxide (SiO_2) in the surface coating layer and the electric current value (KA) necessary for smoothly welding the resultant plated steel strip.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

It was found that a zinc or zinc alloy-surface coating layer plated on a surface of a steel strip and containing specific inorganic dispersoid particles is highly effective for enhancing resistance of the steel strip to corrosion, especially perforation corrosion after the plated steel strip is painted and processed. The reasons for the special effect of the above-mentioned specific zinc or zinc alloy coating layer are not completely clear. It is assumed, however, that the specific inorganic dispersoid particles in the surface coating layer form a sort of barrier against the corrosion so as to restrict undesirable corrosional oxidation-reduction reaction in the coating layer. Also, it was found by the inventors of the present invention that the surface coating layer containing the specific fine inorganic dispersoid particles is effective for enhancing the weldability, especially spot weldability, of the plated steel strip.

Furthermore, it was found by the inventors of the present invention that an intermediate coating layer consisting of zinc or zinc alloy and formed between the steel strip substrate and the surface coating layer containing the specific inorganic dispersoid particles is highly effective for enhancing the specific effects of the surface coating layer, especially, for enhancing the resistance to perforation corrosion of the processed portion and the workability, of the plated steel strip.

The term "workability of the plated steel strip" refers to a resistance of the plated steel strip to powdering of the coating layer, that is, peeling of the coating layer from the substrate when processed.

The reasons for the above-mentioned effects of the intermediate coating layer are not clear. It is supposed, however, that the surface coating layer and the intermediate coating layer have a synergistic effect on, the plated steel strip. Also, it is supposed that the intermediate coating layer exhibits a special type of lubricating effect between the substrate and the surface coating layer.

In the zinc-plated steel strip of the present invention, a substrate consisting of a steel strip has at least one plated surface coating layer consisting essentially of a matrix consisting of a plated zinc alloy and fine dispersoid particles dispersed in the matrix and consisting of at least one member selected from oxides, carbides, nitrides, borides, phosphides and sulfides of aluminum (Al), iron (Fe), titanium (Ti), molybdenum (Mo), copper (Cu), zinc (Zn), nickel (Ni), cobalt (Co), lanthanum (La), cerium (Ce), and silicon (Si).

The steel strip usable as a substrate for the present invention is not limited to specific types of steel strips. However, usually, the steel strip is preferably selected from ordinary steel strips, Al-killed steel strips and high tensile steel strips.

As stated above, when the above-mentioned specific inorganic dispersoid particles are contained in the zinc or zinc alloy matrix, the resultant surface coating layer exhibits an excellent effect in enhancing the resistance to corrosion and workability and weldability of the plated steel strip. These effects of the surface coating layer of the present invention are excellent compared with those of other zinc or zinc alloy coating layers which are free from the specific inorganic dispersoid or contain other dispersoids.

In the zinc-plated steel strips of the present invention, it is preferable that the surface coating layer be in an amount of from 1 to 400 g/m^2, and has a thickness of from 0.1 to 40 microns.

In the surface coating layer, the matrix consists of zinc or a zinc alloy. The zinc alloy is preferably selected from alloys of from 20% to 99.7% by weight of zinc with 0.3% to 80% by weight of at least one additional metal member selected from the group consisting of nickel, copper, cobalt, chromium, tellurium, lanthanium, cerium, iron, and manganese.

In the zinc alloy, the above-mentioned specific additional metal in a content of from 0.3% to 80% by weight is effective for enhancing the paint adhesion of the surface coating layer to the steel strip substrate surface when the surface coating layer is scratched and for improving the resistance of the surface coating layer to corrosion, especially, to perforation corrosion within a strict corrosional environment.

In the surface coating layer, the amount of inorganic dispersoid is preferably 0.01% or more, more preferably from 0.01% to 95%, still more preferably from 0.01% to 30 %, based on the entire weight of the surface coating layer.

When the amount of the inorganic dispersoid in the surface coating layer is less than 0.01%, the resultant plated steel strip exhibits unsatisfactory weldability.

For example, Fig. 1 shows the relationship between the content of inorganic dispersoid consisting of silicon dioxide (SiO_2) dispersed in a surface coating layer matrix consisting of zinc and the electric current value necessary for appropriately spot-welding the resulting zinc plated steel strip. The smaller the necessary welding current value, the higher the spot-weldability of the plated steel strip.

The appropriate spot welding current value can be determined by measuring changes in the size of nuggets formed in response to changes in the spot welding current applied.

Figure 1 clearly shows that when the content of SiO_2 dispersoid is less than 0.01%, the weldability of the plated steel strip is unsatisfactory.

When the plated steel strip is required to exhibit extremely high resistance to corrosion, in view of the sacrifice corrosion control effect of zinc or the zinc alloy, it is preferable that the content of the inorganic dispersoid does not exceed 95% based on the entire weight of the surface coating layer. Also, when the plated steel strip is required to have excellent resistance to powdering after the plated steel strip is strictly processed, it is preferable to limit the content of the inorganic dispersoid to 30% or less based on the entire weight of the surface coating layer.

The fine inorganic dispersoid particles in the surface coating layer preferably have an average size of 5 microns or less, preferably, from 0.01 to 1 micron. Fine inorganic dispersoid particles having an average size of 5 microns or less are highly effective for enhancing the resistance of the resultant plated steel strip to powdering when the strip is subjected to severe processing. The term "average size" refers to a size of the particles in a largest distribution percentage.

The surface coating layer of the present invention may cover the entire surface of the steel strip substrate. Otherwise, the surface of the steel strip substrate may be partially covered by the surface coating layer, for example, in the form of a plurality of stripes.

In the zinc-plated steel strip of the present invention, an intermediate coating layer consisting of zinc or a zinc alloy may be formed between the steel strip substrate and the surface coating layer.

The intermediate coating layer may be formed so as to partially cover or entirely cover the surface of the steel strip substrate. The intermediate coating layer consists of zinc or a zinc alloy. Preferably, the zinc alloy is selected from alloys of 20% to 99% by weight of zinc and 1% to 80% by weight of at least one metal other than zinc, preferably selected from the group consisting of nickel, cobalt, chromium, iron, and molybdenum.

The intermediate coating layer is preferably in an amount of from 0.5 to 400 g/m^2, more preferably, from 1 to 200 g/m^2, and preferably has a thickness of from 0.1 to 20 microns.

The surface coating layer in the zinc-plated steel strip of the present invention may have a covering layer formed thereon by means of a silane-coupling treatment or a chemical conversion treatment.

The term "silane-coupling treatment" refers to a treatment of the surface of the surface coating layer with a silane-coupling agent, for example, vinylchlorosilane or vinyltrimethoxysilane. The term "chemical conversion treatment" refers to a phosphate treatment or a chromate treatment applied to the surface coating layer of the plated steel strip.

The silane-coupling treatment and chemical conversion treatment are effective for enhancing the primary adhering property of the surface of the plated steel strip to lacquer.

The surface coating layer can be produced on a surface of the steel strip substrate by means of an electric plating or a vacuum evaporation plating procedure in the presence of fine inorganic dispersoid particles. Preferably, the electric plating method is applied to the production of the surface coating layer. For example, the electric plating procedure is carried out in a plating bath containing sulfate or chloride of zinc or zinc and at least one additional metal having a pH of 1 to 3 at a current density of 1 to 200 A/dm^2 at a line speed of 1 to 250 m/min.

In the production of the surface coating layer, it is not completely clear how the inorganic dispersoid particles are deposited in the plated metal matrix. It is assumed that the dispersoid particles are deposited due to the attraction caused by static electricity or the mechanical force applied thereto.

The intermediate coating layer can be produced by means of electric plating, vacuum evaporation plating, or hot galvanizing.

The zinc-plated steel strip of the present invention may have only one surface coating layer formed on only one surface of the substrate, two surface coating layers formed on both the surfaces of the substrate, or a combination of a surface coating layer and an intermediate coating layer formed on only one surface of the substrates or on each surface of the substrate.

When one surface of the substrate has a surface coating layer or a combination of an intermediate coating layer and a surface coating layer, the other surface of the substrate may be plated with a coating layer other than the surface coating layer and the intermediate coating layer of the present invention or with the same coating layer as the intermediate coating layer of the present invention.

The present invention will be further explained by way of specific examples, which, however, are representative and do not restrict the scope of the present invention in any way.

In the examples, the resistance of a specimen to corrosion was determined as follows.

A specimen was subjected to a dipping type chemical conversion treatment with zinc phosphate. The treatment specimen was coated with a cathodic ED coating layer having a thickness of 20 microns.

The painted specimen was subjected to a cyclic corrosion test (CCT) in which a salt spray test was combined with a drying-wetting-cooling test.

The specimen was tested for perforation corrosion of the processed portion of the steel strip was of a lapped panel. This test was carried out over 4 weeks, and the maximum depth of pits formed in the specimen was measured. The workability of the specimen was evaluated by a deep drawing test.

The resistance of the deep drawn specimen to powdering was determined by a tape test.

The weldability of the specimen was determined as follows. Two zinc-plated specimens were laid back to back with the plated surfaces outside. These were then spot-welded. The size of the nuggets formed in the welded portion was measured to determine the appropriate welding current for the specimens.

The surface rusting test was carried out by a cross-cut method.

The paint adhesion of the scratched portion of the specimen was determined by a cross-cut method in which the cross-cut specimen was subjected to the CCT for 4 weeks and the maximum width of blisters formed in the specimen was measured. The results of the above-mentioned tests were evaluated as follows:

Perforation corrosion resistance

Result (Maximum depth of pit)	Representation
Less than 0.1 mm	E (Excellent)
0.1 mm or more but less than 0.2 mm	G (Good)
0.2 mm or more but less than 0.3 mm	S (Satisfactory)
0.3 mm or more	B (Bad)

Rusting resistance

Result	Representation
No red rust	E (Excellent)
Very slight red rust	G (Good)
Slight red rust	S (Satisfactory)
Large areas of red rust	B (Bad)

Adhering property

Result (Maximum width of blister)	Representation
Less than 2 mm	E (Excellent)
2 mm or more but less than 3 mm	G (Good)
3 mm or more but less than 5 mm	S (Satisfactory)
5 mm or more	B (Bad)

Powdering resistance

Result	Representation
No change in color of testing tape	E (Excellent)
Very slight black coloring	G (Good)

Slight black coloring	S (Satisfactory)
Remarkable black coloring	B (Bad)

Weldability

Result	Representation
Excellent	E
Good	G
Satisfactory	S
Bad	B

General Evaluation

Result	Representation
Excellent	E
Good	G
Satisfactory	S
Bad	B

Examples 1 to 63

In each of Examples 1 to 63, a surface of a substrate consisting of an ordinary steel strip was plated with a surface coating layer as shown in detail in Table 1 (1), (2), and (3). The properties of the resultant plated steel strips are also shown in Table 1 (1), (2), and (3).

In view of Examples 36 to 42 and 44 to 50, it is preferable that the content of the inorganic dispersoid particles in the surface coating layer be 0.01% or more, based on the entire weight of the surface coating layer, in order to enhance the weldability of the plated steel strip.

In view of Examples 35 to 39 and 43 to 47, it is preferable for the purpose of enhancing the powdering resistance of the plated steel strip to control the content of the inorganic dispersoid particle to a level not exceeding 30% based on the entire weight of the surface coating layer.

In view of Examples 35 to 41 and 43 to 49, it is preferable for the purpose of improving the perforation corrosion resistance of the processed portion of the plated steel strip to control the content of the inorganic dispersoid particles to a level not exceeding 95% based on the entire weight of the surface coating layer.

In view of Examples 51 to 54, it is preferable for the purpose of enhancing the powdering resistance to limit the average size of the inorganic dispersoid particles to a level not exceeding 5 microns.

In view of Examples 1 to 3 and 4 to 15, where the matrix consists of zinc alone, the preferable inorganic dispersoid particles should consist of aluminum, iron, or titanium.

In view of examples 55 to 63, it is preferable for the purpose of enhancing the adhering property of scratched portion of the plated steel strip to control the content of the inorganic dispersoid particles to the level of 0.3% or more based on the entire weight of the surface coating layer. Also, it is preferable for the purpose of enhancing the pitting corrosion resistance and rust resistance to limit the content of the inorganic dispersoid particles to a level not exceeding 80% based on the entire weight of the surface coating layer.

<u>Examples 64 to 251 and Comparative Example 1 to 9</u>

In each of Examples 64 to 251, except for Examples 203, 205, and 207 to 227, a surface of a substrate consisting of an ordinary steel strip was plated with an intermediate coating layer having the composition and thickness as shown in Table 2 (1) to (9) and then with a surface coating layer having the composition and thickness shown in Table 2.

In each of Examples 203, 205, and 207 to 227, the same substrate as that mentioned above was directly plated with a surface coating layer having the composition and thickness as indicated in Table 2.

In Comparative Examples 1 to 6, the same substrate as that mentioned above was plated with an intermediate coating layer and then with a surface coating layer each having the composition and thickness in Table 2 (7).

In Comparative Examples 7 to 9, the same substrate as that mentioned above was plated directly with the surface coating layer as shown in Table 2 (9).

In Example 203, a surface of the substrate was covered partially with the intermediate coating layer at a covering rate of 50%.

In each of Examples 205 and 206, the surface of the surface coating layer was treated with a silane-coupling agent.

In Comparative Example 1, wherein the intermediate coating layer contains SiO_2 particles whereas the surface coating layer is free from the inorganic dispersoid particles, the resultant plated steel strip exhibited a very poor perforation corrosion resistance, whereas the paint adhesion of the scratched portion to lacquer was excellent.

In Comparative Example 2, dispersoid particles consisting of Cr_2O_3 resulted in a poor weldability of the resultant plated steel strip.

In Comparative Examples 3 and 4, a surface coating layer matrix consisting of nickel or manganese resulted in a poor perforation corrosion resistance of the resultant plated steel strip.

In each of Comparative Examples 5 and 6, the surface coating layer contained no inorganic dispersoid. This feature resulted in poor weldability of the resultant plated steel strip.

In each of Comparative Examples 7 and 9 the dispersoid consisting of ZrO_2 or Cr_2O_3 resulted in poor powdering resistance and weldability of the resultant plated steel strip.

In Comparative Example 8, the dispersoid consisting of WC resulted in a poor paint adhesion and in poor weldability of the resultant plated steel strip.

In view of Examples 207 to 216, the preferable dispersoids for the zinc-nickel alloy matrix in the surface coating layer are oxides of aluminum, iron, titanium, and silicon.

In view of Examples 217 and 223, the preferable metals to be alloyed with zinc in the surface coating layer are nickel, cobalt, chromium, iron, and manganese.

In View of Examples 64 to 75, 88 to 99, 112 to 123, and 151 to 160, the resultant plated steel strips having an intermediate coating layer consisting of zinc or a zinc alloy and a surface coating layer containing dispersoid particles consisting of SiO_2 and having an average size of 5 microns or less exhibited excellent corrosion resistance, workability, and weldability and, therefore, are most preferable products of the present invention.

In view of Examples 173 to 180, when the content of the dispersoid particles is 0.01% or more, the resultant plated steel strips exhibited an excellent weldability. When the content is 30% or less, the resultant products exhibited excellent workability. Also, when the content of the dispersoid is 95% or less, the resultant products exhibited excellent perforation corrosion resistance.

In view of Examples 181 to 187, the preferable thickness of the surface coating layer is in the range of from 0.1 to 40 microns. Also, in view of Examples 228 to 232, it is preferable that the thickness of the intermediate coating layer is in the range of from 0.1 to 20 microns.

Examples 190 to 193 suggested that when the average size of the dispersoid particles is 5 microns or less, the resultant plated steel strip exhibited an enhanced powdering resistance.

In view of Examples 194 to 202, it is known that in the surface coating layer matrix consisting of a zinc alloy, when the content of the additional metal to be alloyed with zinc is 0.3% by weight or more, the resultant plated steel strip exhibited an enhanced paint adhesion of a scratched portion. When the content of the additional metal is 80% by weight or less, the processed portion of the plated steel strip exhibited an excellent perforation corrosion resistance.

Examples 203 and 204 showed that the plated steel strips having surface and intermediate coating layers or a surface coating layer in the form of a plurality of stripes are satisfactory.

When the plated steel stripes of the present invention were surface treated with a silane coupling agent, the resultant products exhibited excellent corrosion resistance, workability, and weldability as shown in Examples 205 and 206.

Table 1 (1)

Example No.	Type of surface coating	Composition of coating: Surface coating layer: Composition of matrix	Dispersoid: Type	Dispersoid: Content (wt %)	Dispersoid: Size (μm)	Thickness (μm)	Resistance to corrosion: Perforation corrosion resistance	Resistance to corrosion: Surface rust resistance	Resistance to corrosion: Paint adhesion	Workability (Resistance to powdering)	Weldability	General evaluation
1	Zn - Al_2O_3	Zn(100)	Al_2O_3	5	1	5	G	E	G	G	G	E
2	Zn - Fe_2O_3	"	Fe_2O_3	"	"	"	"	"	"	"	"	"
3	Zn - TiO_2	"	TiO_2	"	"	"	"	"	"	"	"	"
4	Zn - MoO_3	"	MnO_3	"	"	"	"	G	S	"	"	G
5	Zn - CuO	"	CuO	"	"	"	"	"	"	"	"	"
6	Zn - ZnO	"	ZnO	"	"	"	"	"	"	"	"	"
7	Zn - NiO	"	NiO	"	"	"	"	"	"	"	"	"
8	Zn - CoO	"	CoO	"	"	"	"	"	"	"	"	"
9	Zn - La_2O_3	"	La_2O_3	"	"	"	"	"	"	"	"	"
10	Zn - CeO_2	"	CeO_2	"	"	"	"	"	"	"	"	"
11	Zn - TiC	"	TiC	"	"	"	"	"	"	"	"	"
12	Zn - TiB	"	TiB	"	"	"	"	"	"	"	"	"
13	Zn - MoS	"	MoS	"	"	"	"	"	"	"	"	"
14	Zn - BN	"	BN	"	"	"	"	"	"	"	"	"
15	Zn - CuP	"	CuP	"	"	"	"	"	"	"	"	"
16	Zn - SiC	"	SiC	"	"	"	"	"	"	"	"	"
17	Zn - Ni - SiO_2	Zn(83)Ni(13)	SiO_2	"	"	"	"	E	"	"	E	E
18	Zn - Ni - SiC	"	SiC	"	1	"	"	"	"	"	G	"
19	Zn - Ni - Si_3N_4	"	Si_3N_4	"	"	"	"	"	"	"	"	"
20	Zn - Cu - SiC	Zn(70)Cu(30)	SiC	"	"	"	"	"	"	"	"	"

Note: E: Excellent
G: Good
S: Standard
B: Bad

Table 1 (2)

Example No.	Type of surface coating	Composition of coating: Surface coating layer: Composition of matrix	Dispersoid: Type	Dispersoid: Content (wt %)	Dispersoid: Size (μm)	Thickness (μm)	Resistance to corrosion: Perforation corrosion resistance	Resistance to corrosion: Surface rust resistance	Resistance to corrosion: Paint adhesion	Workability (Resistance to powdering)	Weldability	General evaluation
21	Zn - Cu - Al_2O_3	Zn(70)Cu(30)	Al_2O_3	5	1	5	G	E	G	G	G	E
22	Zn - Co - SiO_2	Zn(85)Co(15)	SiO_2	"	0.02	"	"	"	"	"	E	"
23	Zn - Fe - SiO_2	Zn(85)Fe(15)	SiO_2	"	"	"	"	"	"	"	E	"
24	Zn - Cr - SiO_2	Zn(85)Cr(15)	SiO_2	"	"	"	"	"	"	"	G	"
25	Zn - Tl - Al_2O_3	Zn(95)Tl(5)	Al_2O_3	"	1	"	"	"	"	"	"	"
26	Zn - La - SiO_2	Zn(95)La(5)	SiO_2	"	0.02	"	"	"	"	"	"	"
27	Zn - Ce - Al_2O_3	Zn(95)Ce(5)	Al_2O_3	"	1	"	"	"	"	"	"	"
28	Zn - Mn - Al_2O_3	Zn(85)Mn(15)	"	"	"	"	"	G	"	"	"	G
29	Zn - Ni - TiB	Zn(85)Ni(15)	TiB	"	"	"	"	"	"	"	"	"
30	Zn - Ni - MoS	"	MoS	"	"	"	"	"	"	"	"	"
31	Zn - Ni - BN	"	BN	"	"	"	"	"	"	"	"	"
32	Zn - Ni - CuP	"	CuP	"	"	"	"	"	"	"	"	"
33	Zn - Al_2O_3 - TiC	Zn(100)	Al_2O_3 TiC	5 5	"	"	"	"	S	"	"	"
34	Zn - Ni - Al_2O_3 - TiC	Zn(87)Ni(13)	Al_2O_3 TiC	5 5	"	"	"	"	G	"	"	"
35	Zn - Al_2O_3	Zn(100)	Al_2O_3	0.008	"	"	"	"	"	"	S	"
36	"	"	"	0.01	"	"	"	"	"	"	G	"
37	"	"	"	0.05	"	"	"	"	"	"	"	"
38	"	"	"	10	"	"	"	"	"	"	"	"

Table 1 (3)

Example No.	Type of surface coating	Composition of coating: Surface coating layer: Composition of matrix	Dispersoid: Type	Dispersoid: Content (wt %)	Dispersoid: Size (μm)	Thickness (μm)	Resistance to corrosion: Perforation corrosion resistance	Resistance to corrosion: Surface rust resistance	Resistance to corrosion: Paint adhesion	Workability (Resistance to powdering)	Weldability	General evaluation
39	Zn - Al_2O_3	Zn(100)	Al_2O_3	25	1	5	G	G	G	G	G	G
40	"	"	"	32	"	"	"	"	"	S	"	"
41	"	"	"	93	"	"	"	"	"	"	"	"
42	"	"	"	98	"	"	S	"	"	"	"	"
43	Zn - Ni - SiC	Zn(87)Ni(13)	SiC	0.005	"	"	G	"	"	G	S	"
44	"	"	"	0.01	"	"	"	"	"	"	G	"
45	"	"	"	0.02	"	"	"	"	"	"	E	"
46	"	"	"	12	"	"	"	"	"	"	E	"
47	"	"	"	28	"	"	"	"	"	"	E	"
48	"	"	"	31	"	"	"	"	"	S	G	"
49	"	"	"	92	"	"	"	"	"	"	"	"
50	"	"	"	96	"	"	S	"	"	"	"	"
51	Zn - Al_2O_3	Zn(100)	Al_2O_3	25	2	"	G	"	"	G	"	"
52	"	"	"	"	3	"	"	"	"	"	"	"
53	"	"	"	5	5	5	"	"	"	"	"	"
54	"	"	"	7	"	"	"	"	"	S	"	"
55	Zn - Ni - SiC	Zn(99.8)Ni(0.2)	SiC	1	"	"	"	"	S	G	"	"
56	"	Zn(99.7)Ni(0.3)	"	"	"	"	"	"	"	"	"	"
57	"	Zn(98)Ni(2)	"	"	"	"	"	"	"	"	"	"
58	"	Zn(95)Ni(5)	"	"	"	"	"	"	"	"	"	"

Table 1 (4)

Example No.	Type of surface coating	Composition of coating					Resistance to corrosion			Workability (Resistance to powdering)	Weldability	General evaluation
		Surface coating layer										
		Composition of matrix	Dispersoid			Thickness (μm)	Perforation corrosion resistance	Surface rust resistance	Paint adhesion			
			Type	Content (wt %)	Size (μm)							
59	Zn - Ni - SiC	Zn(70)Ni(30)	SiC	1	5	5	G	G	S	G	G	G
60	"	Zn(40)Ni(60)	"	"	"	"	"	"	"	"	"	"
61	"	Zn(20)Ni(80)	"	"	"	"	"	"	"	"	"	"
62	"	Zn(15)Ni(85)	"	"	"	"	S	S	"	"	"	"
63	"	Zn(10)Ni(90)	"	"	"	"	S	S	"	"	"	"

Table 2 (1)

Example No.	Type of coating Surface/Intermediate	Composition of coating: Surface coating layer: Composition of matrix	Surface coating layer: Dispersoid: Type	Surface coating layer: Dispersoid: Content (wt %)	Surface coating layer: Dispersoid: Size (μm)	Surface coating layer: Thickness (μm)	Intermediate coating layer: Composition	Intermediate coating layer: Thickness (μm)	Resistance to corrosion: Perforatoin corrosion resistance	Resistance to corrosion: Surface rust resistance	Resistance to corrosion: Paint adhesion	Workability (Resistance to powdering)	Weldability	General evaluation
64	Zn - SiO_2/Zn	Zn(100)	SiO_2	1	0.02	2.5	Zn(100)	2.5	E	E	E	E	E	E
65	"	"	"	25	"	"	"	"	"	"	"	"	"	"
66	"	"	"	5	"	"	"	"	"	"	"	"	"	"
67	"	"	"	10	"	"	"	"	"	"	"	"	"	"
68	Zn - Co-coated SiO_2/Zn	"	"	1	"	"	"	"	"	"	G	"	"	"
69	"	"	"	28	"	"	"	"	"	"	"	"	"	"
70	"	"	"	5	"	"	"	"	"	"	"	"	"	"
71	"	"	"	10	"	"	"	"	"	"	"	"	"	"
72	Zn - Mg-coated SiO_2/Zn	"	"	1	"	"	"	"	"	"	"	"	"	"
73	"	"	"	30	"	"	"	"	"	"	"	"	"	"
74	"	"	"	5	"	"	"	"	"	"	"	"	"	"
75	"	"	"	10	"	"	"	"	"	"	"	"	"	"
76	Zn - AlO_3/Zn	"	Al_2O_3	1	0.5	"	"	"	"	"	"	"	"	"
77	"	"	"	28	"	"	"	"	"	"	"	"	"	"
78	"	"	"	5	"	"	"	"	"	"	"	"	"	"
79	"	"	"	10	"	"	"	"	"	"	"	"	"	"
80	Zn - Fe_2O_3/Zn	"	Fe_2O_3	1	"	"	"	"	"	"	"	"	"	"
81	"	"	"	25	"	"	"	"	"	"	"	"	"	"
82	"	"	"	5	"	"	"	"	"	"	"	"	"	"
83	"	"	"	10	"	"	"	"	"	"	"	"	"	"

Table 2 (2)

Example No.	Type of coating Surface/Intermediate	Composition of coating: Surface coating layer: Composition of matrix	Dispersoid: Type	Dispersoid: Content (wt %)	Dispersoid: Size (µm)	Thickness (µm)	Intermediate coating layer: Composition	Thickness (µm)	Resistance to corrosion: Perforation corrosion resistance	Surface rust resistance	Paint adhesion	Workability (Resistance to powdering)	Weldability	General evaluation
84	Zn - TiO_2/Zn	Zn(100)	TiO_2	1	0.5	2.5	Zn(100)	2.5	E	E	G	E	E	E
85	"	"	"	30	"	"	"	"	"	"	"	"	"	"
86	"	"	"	5	"	"	"	"	"	"	"	"	"	"
87	"	"	"	10	"	"	"	"	"	"	"	"	"	"
88	Zn - Fe - SiO_2/Zn	Zn(85)Fe(15)	SiO_2	1	0.02	"	"	"	"	"	E	"	"	"
89	"	"	"	30	"	"	"	"	"	"	"	"	"	"
90	"	"	"	5	"	"	"	"	"	"	"	"	"	"
91	"	"	"	50	"	"	"	"	"	"	"	G	"	G
92	Zn - Fe - Co-coated SiO_2/Zn	"	"	1	"	"	"	"	"	"	"	E	"	E
93	"	"	"	30	"	"	"	"	"	"	"	"	"	"
94	"	"	"	5	"	"	"	"	"	"	"	G	"	"
95	"	"	"	50	"	"	"	"	"	"	"	"	"	G
96	Zn - Fe - Mg-coated SiO_2/Zn	"	"	1	"	"	"	"	"	"	"	E	"	E
97	"	"	"	25	"	"	"	"	"	"	"	"	"	E
98	Zn - Fe - Mg-coated SiO_2/Zn	"	"	5	"	"	"	"	"	"	"	"	"	E
99	"	"	"	50	"	"	"	"	"	"	"	G	"	G
100	Zn - Fe - Al_2O_3/Zn	"	Al_2O_3	1	0.5	"	"	"	"	"	"	E	"	E
101	"	"	"	26	"	"	"	"	"	"	"	"	"	"
102	"	"	"	5	"	"	"	"	"	"	"	"	"	"
103	"	"	"	50	"	"	"	"	"	"	"	G	"	G

Table 2 (3)

Example No.	Type of coating Surface/Intermediate	Composition of coating: Surface coating layer: Composition of matrix	Surface coating layer: Dispersoid: Type	Dispersoid: Content (wt %)	Dispersoid: Size (μm)	Surface coating layer: Thickness (μm)	Intermediate coating layer: Composition	Intermediate coating layer: Thickness (μm)	Resistance to corrosion: Perforation corrosion resistance	Resistance to corrosion: Surface rust resistance	Resistance to corrosion: Paint adhesion	Workability (Resistance to powdering)	Weldability	General evaluation
104	Zn - Fe - Fe_2O_3/Zn	Zn(85)Fe(15)	Fe_2O_3	1	0.5	2.5	Zn(100)	2.5	E	E	E	E	E	E
105	"	"	"	27	"	"	"	"	"	"	"	"	"	"
106	"	"	"	5	"	"	"	"	"	"	"	"	"	"
107	"	"	"	50	"	"	"	"	"	"	"	G	"	G
108	Zn - Fe - TiO_2/Zn	"	TiO_2	1	"	"	"	"	"	"	"	E	"	E
109	"	"	"	25	"	"	"	"	"	"	"	"	"	"
110	"	"	"	5	"	"	"	"	"	"	"	"	"	"
111	"	"	"	50	"	"	"	"	"	"	"	G	"	G
112	Zn - Ni - SiO_2/Zn	Zn(87)Ni(13)	SiO_2	1	0.02	"	"	"	"	"	"	E	"	E
113	"	"	"	28	"	"	"	"	"	"	"	"	"	"
114	"	"	"	5	"	"	"	"	"	"	"	"	"	"
115	"	"	"	50	"	"	"	"	"	"	"	G	"	G
116	Zn - Ni - Co-coated SiO_2/Zn	"	"	1	"	"	"	"	"	"	"	E	"	E
117	"	"	"	26	"	"	"	"	"	"	"	"	"	"
118	"	"	"	5	"	"	"	"	"	"	"	"	"	"
119	"	"	"	50	"	"	"	"	"	"	"	G	"	G
120	Zn - Ni - Mg-coated SiO_2/Zn	"	"	1	"	"	"	"	"	"	"	E	"	E
121	"	"	"	28	"	"	"	"	"	"	"	"	"	"
122	"	"	"	5	"	"	"	"	"	"	"	"	"	"
123	"	"	"	50	"	"	"	"	"	"	"	G	"	G
124	Zn - Ni - Al_2O_3/Zn	"	Al_2O_3	1	0.5	"	"	"	"	"	"	"	"	"

Table 2 (4)

Example No.	Type of coating Surface/Intermediate	Composition of coating: Surface coating layer: Composition of matrix	Surface coating layer: Dispersoid: Type	Dispersoid: Content (wt %)	Dispersoid: Size (μm)	Surface coating layer: Thickness (μm)	Intermediate coating layer: Composition	Intermediate coating layer: Thickness (μm)	Resistance to corrosion: Perforation corrosion resistance	Resistance to corrosion: Surface rust resistance	Resistance to corrosion: Paint adhesion	Workability (Resistance to powdering)	Weldability	General evaluation
125	Zn - Ni - Al_2O_3/Zn	Zn(87)Ni(13)	Al_2O_3	26	0.5	2.5	Zn(100)	2.5	E	E	E	G	E	G
126	"	"	"	5	"	"	"	"	"	"	"	"	"	"
127	"	"	"	50	"	"	"	"	"	"	"	"	"	"
128	Zn - Ni -Fe_2O_3/Zn	"	Fe_2O_3	1	"	"	"	"	"	"	"	"	"	"
129	"	"	"	28	"	"	"	"	"	"	"	"	"	"
130	"	"	"	5	"	"	"	"	"	"	"	"	"	"
131	"	"	"	50	"	"	"	"	"	"	"	"	"	"
132	Zn - Ni - TiO_2/Zn	"	TiO_2	1	"	"	"	"	"	"	"	"	G	"
133	"	"	"	27	"	"	"	"	"	"	"	"	"	"
134	"	"	"	5	"	"	"	"	"	"	"	"	"	"
135	"	"	"	50	"	"	"	"	"	"	"	"	"	"
136	Zn - SiC/Zn	Zn(100)	SiC	1	"	"	"	"	G	G	G	"	"	"
137	Zn - TiC/Zn	"	TiC	"	"	"	"	"	"	"	"	"	"	"
138	Zn - SiN/Zn	"	SiN	"	"	"	"	"	"	"	"	"	"	"
139	Zn - TiN/Zn	"	TiN	"	"	"	"	"	"	"	"	"	"	"
140	Zn - AlN/Zn	"	AlN	"	"	"	"	"	"	"	"	"	"	"
141	Zn - Fe - SiC/Zn	Zn(85)Fe(15)	SiC	"	"	"	"	"	E	E	E	"	"	"
142	Zn - Fe - TiC/Zn	"	TiC	"	"	"	"	"	"	"	"	"	"	"
143	Zn - Fe - SiN/Zn	"	SiN	"	"	"	"	"	"	"	"	"	"	"
144	Zn - Fe - TiN/Zn	"	TiN	"	"	"	"	"	"	"	"	"	"	"
145	Zn - Fe - AlN/Zn	"	AlN	"	"	"	"	"	"	"	"	"	"	"
146	Zn - Ni - SiC/Zn	Zn(87)Ni(13)	SiC	"	"	"	"	"	"	"	"	"	"	"
147	Zn - Ni - TiC/Zn	"	TiC	"	"	"	"	"	"	"	"	"	"	"

Table 2 (5)

Example No.	Type of coating Surface/Intermediate	Composition of coating: Surface coating layer: Composition of matrix	Surface coating layer: Dispersoid: Type	Dispersoid: Content (wt %)	Dispersoid: Size (μm)	Surface coating layer: Thickness (μm)	Intermediate coating layer: Composition	Intermediate coating layer: Thickness (μm)	Resistance to corrosion: Perforation corrosion resistance	Resistance to corrosion: Surface rust resistance	Resistance to corrosion: Paint adhesion	Workability (Resistance to powdering)	Weldability	General evaluation
148	Zn - Ni - SiN/Zn	Zn(87)Ni(13)	SiN	1	0.5	2.5	Zn(100)	2.5	E	E	E	G	G	G
149	Zn - Ni - TiN/Zn	"	TiN	"	"	"	"	"	"	"	"	"	"	"
150	Zn - Ni - AlN/Zn	"	AlN	"	"	"	"	"	"	"	"	"	"	"
151	Zn - SiO_2/Zn - Fe	Zn(100)	SiO_2	"	0.02	"	Zn(85)Fe(15)	"	"	"	"	E		E
152	Zn - Fe - SiO_2/Zn - Fe	Zn(85)Fe(15)	"	"	"	"	"	"	"	"	"	"		"
153	Zn - Ni - SiO_2/Zn - Fe	Zn(87)Ni(13)	"	"	"	"	Zn(85)Ni(15)	"	"	"	"	"		"
154	Zn - SiO_2/Zn - Ni	Zn(100)	"	"	"	"	"	"	G	G	G	"		"
155	Zn - Fe - SiO_2/Zn - Ni	Zn(85)Fe(15)	"	"	"	"	"	"	E	E	E	"		"
156	Zn - Ni - SiO_2/Zn - Ni	Zn(85)Ni(15)	"	"	"	"	"	"	"	"	"	"		"
157	Zn - Co-coated SiO_2 - SiO_2/Zn	Zn(100)	Co-coated SiO_2	1	"	"	Zn(100)	"	"	"	"	"		"
			SiO_2	1										
158	Zn - Mg-coated SiO_2 - SiO_2/Zn	"	Mg-coated SiO_2	1	"	"	"	"	"	"	"	"		"
			SiO_2	1										
159	Zn - SiO_2 - SiC/Zn	"	SiO_2	1	0.5	"	"	"	"	"	"	"		"
			SiC	1										
160	Zn - SiO_2 - SiN/Zn	"	SiO_2	1	"	"	"	"	"	"	"	"		"
			SiN	1										
161	Zn - SiC - SiN/Zn	"	SiC	1	"	"	"	"	"	"	"	"		"
			SiN	1										
162	Zn-TiB/Zn	Zn(100)	TiB	"	1	2.5	"	"	"	"	G	"	G	G

Table 2 (6)

Example No.	Type of coating Surface/Intermediate	Composition of coating: Surface coating layer: Composition of matrix	Dispersoid: Type	Dispersoid: Content (wt %)	Dispersoid: Size (μm)	Surface coating layer: Thickness (μm)	Intermediate coating layer: Composition	Intermediate coating layer: Thickness (μm)	Resistance to corrosion: Perforation corrosion resistance	Resistance to corrosion: Surface rust resistance	Paint adhesion	Workability (Resistance to powdering)	Weldability	General evaluation
163	Zn - MoS/Zn	Zn(100)	MoS	1	1	2.5	Zn(100)	2.5	E	E	G	E	G	G
164	Zn - MoO_3/Zn	"	MoO_3	"	"	"	"	"	"	"	"	"	"	"
165	Zn - CuO/Zn	"	CuO	"	"	"	"	"	"	"	"	"	"	"
166	Zn - ZnO/Zn	"	ZnO	"	"	"	"	"	"	"	"	"	"	"
167	Zn - NiO/Zn	"	NiO	"	"	"	"	"	"	"	"	"	"	"
168	Zn - CoO/Zn	"	CoO	"	"	"	"	"	"	"	"	"	"	"
169	Zn - La_2O_3/Zn	"	La_2O_3	"	"	"	"	"	"	"	"	"	"	"
170	Zn - CeO_2/Zn	"	CeO_2	"	"	"	"	"	"	"	"	"	"	"
171	Zn - TiB/Zn-Ni	"	TiB	"	"	"	Zn(87)Ni(13)	"	"	"	"	"	"	"
172	Zn - TiB/Zn-Fe	"	"	"	"	"	Zn(85)Fe(15)	"	"	"	"	"	"	"
173	Zn - Al_2O_3/Zn	"	Al_2O_3	0.008	"	"	Zn(100)	"	G	"	E	"	S	"
174	"	"	"	0.01	"	"	"	"	G	"	E	"	G	"
175	"	"	"	0.05	"	"	"	"	E	"	G	"	"	"
176	"	"	"	10	"	"	"	"	"	"	"	"	"	"
177	"	"	"	25	"	"	"	"	"	"	"	"	"	"
178	"	"	"	32	"	"	"	"	"	"	E	G	"	"
179	"	"	"	93	"	"	"	"	"	"	E	S	"	"
180	"	"	"	98	"	"	"	"	G	"	G	S	"	"

Table 2 (7)

Example No.	Type of coating Surface/Intermediate	Composition of coating: Surface coating layer: Composition of matrix	Surface coating layer: Dispersoid: Type	Dispersoid: Content (wt %)	Dispersoid: Size (μm)	Surface coating layer: Thickness (μm)	Intermediate coating layer: Composition	Intermediate coating layer: Thickness (μm)	Resistance to corrosion: Perforation corrosion resistance	Resistance to corrosion: Surface rust resistance	Resistance to corrosion: Paint adhesion	Workability (Resistance to powdering)	Weldability	General evaluation
181	Zn - Ni - Sic/Zn - Ni	Zn(87) Ni(13)	SiC	1	1	0.05	Zn(87)Ni(13)	2.5	E	G	G	E	S	G
182	"	"	"	"	"	0.1	"	"	"	G	"	"	S	"
183	"	"	"	"	"	1	"	"	"	E	E	"	G	"
184	"	"	"	"	"	10	"	"	"	"	"	"	E	"
185	"	"	"	"	"	20	"	"	"	"	"	"	"	"
186	"	"	"	1	"	40	"	"	"	"	"	"	"	"
187	"	"	"	"	"	50	"	"	"	"	"	S	"	"

Table 2 (8)

Example No.	Type of coating Surface/Intermediate	Composition of coating: Surface coating layer: Composition of matrix	Surface coating layer: Dispersoid: Type	Surface coating layer: Dispersoid: Content (wt %)	Surface coating layer: Dispersoid: Size (μm)	Surface coating layer: Thickness (μm)	Intermediate coating layer: Composition	Intermediate coating layer: Thickness (μm)	Resistance to corrosion: Perforation corrosion resistance	Resistance to corrosion: Surface rust resistance	Resistance to corrosion: Paint adhesion	Workability (Resistance to powdering)	Weldability	General evaluation
188	Zn - Ni - SiC/Zn - Ni	Zn(87)Ni(13)	SiC	92	1	2.5	Zn(87)Ni(13)	2.5	G	E	E	S	E	G
189	"	"	"	96	"	"	"	"	S	"	"	S	"	"
190	Zn - Al_2O_3/Zn	Zn(100)	Al_2O_3	25	2	"	Zn(100)	"	E	"	G	G	"	"
191	"	"	"	"	3	"	"	"	"	"	"	G	"	"
192	"	"	"	"	5	"	"	"	"	"	"	G	"	"
193	"	"	"		7	"	"	"	"	"	"	S	"	"
194	Zn - Ni - SiC/Zn - Ni	Zn(99.8) Ni(0.2)	SiC	5	1	"	Zn(87)Ni(13)	"	"	"	S	E	"	"
195	"	Zn(99.7) Ni(0.3)	"	"	"	"	"	"	"	"	E	"	"	"
196	"	Zn(98) Ni(2)	"	"	"	"	"	"	"	"	"	"	"	"
197	"	Zn(95) Ni(5)	"	"	"	"	"	"	"	"	"	"	"	"
198	"	Zn(70) Ni(30)	"	"	"	"	"	"	"	"	"	"	"	"
199	"	Zn(40) Ni(60)	"	"	"	"	"	"	G	G	"	"	G	"
200	"	Zn(20) Ni(80)	"	"	"	"	"	"	G	G	"	"	"	"
201	"	Zn(15) Ni(85)	"	"	"	"	"	"	S	S	"	"	"	"
202	"	Zn(10) Ni(90)	"	"	"	"	"	"	S	S	"	"	"	"

Table 2 (9)

	Example No.	Type of coating Surface/Intermediate	Composition of coating: Surface coating layer: Composition of matrix	Dispersoid: Type	Dispersoid: Content (wt %)	Dispersoid: Size (μm)	Thickness (μm)	Intermediate coating layer: Composition	Intermediate coating layer: Thickness (μm)	Resistance to corrosion: Perforation corrosion resistance	Resistance to corrosion: Surface rust resistance	Paint adhesion	Workability (Resistance to powdering)	Weldability	General evaluation
Comparative Example	1	Zn/Zn - SiO_2	Zn(100)	-	-	-	"	Zn(100) *1	"	B	G	"	S	S	B
	2	Zn - Ni - Cr_2O_3/Zn - Ni	Zn(89)Ni(13)	Cr_2O_3	5	1	"	Zn(87)Ni(17)	"	S	G	G	G	B	"
	3	Ni - SiC/Ni	Ni(100)	SiC	"	"	"	Ni(100)	"	B	S	G	"	S	"
	4	Mn - SiC/Zn	Mn(100)	"	"	"	"	Zn(100)	"	B	S	G	"	S	"
	5	Zn - Fe/Zn - Fe	Zn(20)Fe(80)	-	-	-	"	Zn(85)Fe(15)	"	S	S	E	"	B	S
	6	Zn - Ni/none	Zn(87)Ni(13)	-	-		5	-	-	S	S	E	"	B	S
Example	203	Zn - Ni - SiC/none (*)$_2$	Zn(87)Ni(13)	SiC	5	1	5	-	-	E	G	G	G	E	G
	204	Zn - Ni - SiO_2/Zn (*)$_2$	"	SiO_2	"	0.02	2.5	Zn(100)	"	"	E	E	E	"	E
	205	Zn - Ni - SiC/none (*)$_3$	"	SiC	"	1	5	-	-	"	"	"	"	"	"
	206	Zn - Ni - SiO_2/Zn (*)$_3$	"	SiO_2	"	0.02	2.5	Zn(100)	"	"	"	"	"	"	"
	207	Zn - Ni - Al_2O_3	Zn(90)Ni(10)	Al_2O_3	7	1	5	-	-	G	"	"	G	"	"
	208	Zn - Ni - Fe_2O_3	"	Fe_2O_3	"	"	"	-	-	"	"	"	"	"	"
	209	Zn - Ni - TiO_2	"	TiO_2	"	"	"	-	-	"	"	"	"	"	"
	210	Zn - Ni - SiO_2	"	SiO_2	"	"	"	-	-	"	"	"	E	"	"
	211	Zn - Ni - CuO	"	CuO	"	"	"	-	-	"	G	G	G	S	G
	212	Zn - Ni - MoO_3	"	MoO_3	"	"	"	-	-	"	"	"	S	G	"
	213	Zn - Ni - ZnO	"	ZnO	"	"	"	-	-	"	"	"	S	"	"

Note: (*)$_1$ - Intermediate coating layer contained 5% by weight of SiO_2 particles having an average size of 0.02 μm

(*)$_2$ - The intermediate coating layer consisting of zinc alone was formed in the form of a plurality of stripes so as to partially cover the surface of the substrate at a covering rate of 50%.

(*)$_3$ - The surface of the surface coating layer was treated with a silane-coupling agent.

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Table 2 (10)

Example No.	Type of coating Surface/Intermediate	Composition of coating: Surface coating layer: Composition of matrix	Dispersoid: Type	Dispersoid: Content (wt %)	Dispersoid: Size (μm)	Thickness (μm)	Intermediate coating layer: Composition	Intermediate coating layer: Thickness (μm)	Resistance to corrosion: Perforation corrosion resistance	Resistance to corrosion: Surface rust resistance	Resistance to corrosion: Paint adhesion	Workability (Resistance to powdering)	Weldability	General evaluation
214	Zn - Ni - NiO	Zn(90)Ni(10)	NiO	7	1	5	-	-	G	G	G	G	G	G
215	Zn - Ni - La_2O_3	"	La_2O_3	"	"	"	-	-	"	"	"	"	S	"
216	Zn - Ni - CeO_2	"	CeO_2	"	"	"	-	-	"	"	"	"	S	"
217	Zn - Ni - SiO_2	Zn(80)Ni(20)	SiO_2	"	"	"	-	-	"	E	E	"	G	E
218	Zn - Co - SiO_2	Zn(80)Co(20)	SiO_2	"	"	"	-	-	"	"	"	"	"	"
219	Zn - Cr - SiO_2	Zn(80)Cr(20)	"	"	"	"	-	-	"	"	"	"	"	"
220	Zn - Fe - SiO_2	Zn(80)Fe(20)	"	"	"	"	-	-	"	"	"	E	"	"
221	Zn - Mn - SiO_2	Zn(80)Mn(20)	"	"	"	"	-	-	"	"	"	E	"	"
222	Zn - Tl - SiO_2	Zn(80)Tl(20)	"	"	"	"	-	-	"	G	G	G	"	G
223	Zn - Ce - SiO_2	Zn(80)Ce(20)	"	"	"	"	-	-	"	S	G	"	"	G
224	Zn - Ni - Cr - SiO_2	Zn(82)Ni(13) Cr(5)	"	"	"	"	-	-	"	E	E	"	"	E
225	Zn - Ni - Co - SiO_2	Zn(86)Ni(13) Cr(1)	"	"	"	"	-	-	"	"	"	"	"	"
226	Zn - Fe - Co - SiO_2	Zn(84)Fe(15) Cr(1)	"	"	"	"	-	-	"	"	"	"	"	"
227	Zn - Fe - Co - Cr - SiO_2	Zn(79)Fe(15) Ca(1)Cr(5)	"	"	"	"	-	-	"	"	"	"	"	"
228	Zn - Ni - SiC/Zn	Zn(87)Ni(13)	SiC	"	"	"	Zn(100)	0.05	"	"	"	E	"	"
229	"	"	"	"	"	"	"	0.1	E	"	"	"	E	"
230	"	"	"	"	"	"	"	10	"	"	"	"	"	"

Table 2 (11)

Example No.	Type of coating Surface/Intermediate	Composition of coating: Surface coating layer: Composition of matrix	Surface coating layer: Dispersoid: Type	Dispersoid: Content (wt %)	Dispersoid: Size (μm)	Surface coating layer: Thickness (μm)	Intermediate coating layer: Composition	Intermediate coating layer: Thickness (μm)	Resistance to corrosion: Perforation corrosion resistance	Resistance to corrosion: Surface rust resistance	Resistance to corrosion: Paint adhesion	Workability (Resistance to powdering)	Weldability	General evaluation
231	Zn - Ni - SiC/Zn	Zn(87)Ni(13)	SiC	7	1	5	Zn(100)	20	E	E	E	E	E	E
232	"	"	"	"	"	"	"	25	"	"	"	G	"	"
233	Zn - Ni - Al_2O_3/Zn - Ni	Zn(90)Ni(10)	Al_2O_3	7	1	2.5	Zn(87)Ni(13)	2.5	"	"	"	E	"	"
234	Zn - Ni - Fe_2O_3/Zn - Ni	"	Fe_2O_3	"	"	"	"	"	"	"	"	"	"	"
235	Zn - Ni - TiO_2/Zn - Ni	"	TiO_2	"	"	"	"	"	"	"	"	"	"	"
236	Zn - Ni - SiO_2/Zn - Ni	"	SiO_2	"	"	"	"	"	"	"	"	"	"	"
237	Zn - Ni - CuO/Zn - Ni	"	CuO	"	"	"	"	"	"	G	G	"	G	G
238	Zn - Ni - MoO_3/Zn - Ni	"	MoO_3	"	"	"	"	"	"	"	"	"	"	"
239	Zn - Ni - ZnO/Zn - Ni	"	ZnO	"	"	"	"	"	"	"	"	"	"	"
240	Zn - Ni - NiO/Zn - Ni	"	NiO	"	"	"	"	"	"	"	"	"	"	"
241	Zn - Ni - La_2O_3/Zn - Ni	"	La_2O_3	"	"	"	"	"	"	"	"	"	"	"
242	Zn - Ni - CeO_2/Zn - Ni	"	CeO_2	"	"	"	"	"	"	"	"	"	"	"
243	Zn - Ni - SiO_2/Zn - Ni	Zn(80)Ni(20)	SiO_2	"	"	"	"	"	"	E	E	"	E	E
244	Zn - Co - SiO_2/Zn - Ni	Zn(80)Co(20)	"	"	"	"	"	"	"	"	"	"	"	"
245	Zn - Cr - SiO_2/Zn - Ni	Zn(80)Cr(20)	"	"	"	"	"	"	"	"	"	"	"	"
246	Zn - Fe - SiO_2/Zn - Ni	Zn(80)Fe(20)	"	"	"	"	"	"	"	"	"	"	"	"
247	Zn - Mn - SiO_2/Zn - Ni	Zn(80)Mn(20)	"	"	"	"	"	"	"	"	"	"	"	"
248	Zn - Tl - SiO_2/Zn - Ni	Zn(80)Tl(20)	"	"	"	"	"	"	"	G	G	"	G	G
249	Zn - Ce - SiO_2/Zn - Ni	Zn(80)Ce(20)	"	"	"	"	"	"	"	G	G	"	G	G

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Table 2 (12)

	Example No.	Type of coating Surface/Intermediate	Composition of coating							Resistance to corrosion					
			Surface coating layer					Intermediate coating layer							
			Composition of matrix	Dispersoid			Thickness (µm)	Composition	Thickness (µm)	Perforation corrosion resistance	Surface rust resistance	Paint adhesion	Workability (Resistance to powdering)	Weldability	General evaluation
				Type	Content (wt %)	Size (µm)									
Example	250	Zn - Ni - Co - SiO_2/Zn - Ni	Zn(80)Ni(10) Co(30)	SiO_2	7	1	2.5	Zn(87)Ni(13)	2.5	E	E	E	E	E	E
	251	Zn - Fe - Co - SiO_2/Zn - Ni	Zn(80)Fe(10) Co(10)	"	"	"	"	"	"	"	"	"	"	"	"
Comparative Example	7	Zn - ZrO_2	Zn(100)	ZrO_2	5	"	5	-	-	S	S	G	B	B	B
	8	Zn - Ni - WC	Zn(87)Ni(13)	WC	"	"	"	-	-	B	S	B	G	B	B
	9	Zn - Ni - Cr_2O_3	"	Cr_2O_3	"	"	"	-	-	S	G	G	B	B	B

CLAIMS

1. A zinc-plated steel strip with a zinc-based-coating layer, comprising:

a substrate consisting of a steel strip; and

at least one surface coating layer plated on at least a portion of at least one surface of the steel strip substrate,

the surface coating layer consisting essentially of a matrix consisting of at least one member selected from the group consisting of zinc and zinc alloys and fine dispersoid particles dispersed in the matrix and consisting of at least one member selected from the group consisting of oxides, carbides, nitrides, borides, phosphides and sulfides of aluminum, iron, titanium, molybdenum, copper, zinc, nickel, cobalt, lanthanum, cerium, and silicon.

2. The zinc-plated steel strip as claimed in claim 1, wherein, in the surface coating layer, the matrix consists of zinc and the fine dispersoid particles consist of at least one member selected from the group consisting of oxides, carbides, nitrides, borides, phosphides and sulfides of aluminum, iron, titanium, molybdenum, copper, zinc, nickel, cobalt, lanthanum, and cerium.

3. The zinc-plated steel strip as claimed in claim 1, wherein, in the surface coating layer, the matrix consists of at least one zinc alloy and the fine dispersoid particles consist of at least one member selected from the group consisting of oxides, carbides, nitrides, borides, phosphides and sulfides of aluminum, iron titanium, molybdenum, copper, zinc, nickel, cobalt, lanthanum, cerium, and silicon.

4. The zinc-plated steel strip as claimed in claim 1, 2, or 3, wherein the zinc alloy is selected from alloys of zinc with at least one additional metal member selected from the group consisting of nickel,

copper, cobalt, chromium, tellurium, lanthanum, cerium, iron, and manganese.

5. The zinc-plated steel strip as claimed in claim 1, which further comprises an intermediate coating layer formed between the steel strip substrate and the surface coating layer and consisting of at least one member selected from the group consisting of zinc and zinc alloys.

6. The zinc-plated steel strip as claimed in claim 5, wherein the surface coating layer covers partially the surface of the steel strip substrate.

7. The zinc-plated steel strip as claimed in claim 5, wherein the intermediate coating layer partially covers the surface of the steel strip substrate.

8. The zinc-plated steel strip as claimed in claim 1, wherein the fine dispersoid particles are in an amount of at least 0.01% based on the entire weight of the surface coating layer.

9. The zinc-plated steel strip as claimed in claim 1, wherein the fine dispersoid particles are in an amount of from 0.01% to 95% based on the entire weight of the surface coating layer.

10. The zinc-plated steel strip as claimed in claim 9, wherein the fine dispersoid particles are in an amount of from 0.01% to 30% based on the entire weight of the surface costing layer.

11. The zinc-plated steel strip as claimed in claim 1 or 5, which further comprises a covering layer formed on the surface coating layer by means of a silane-coupling treatment or a chemical conversion treatment.

12. The zinc-plated steel strip as claimed in claim 10, wherein the fine dispersoid particles consisting of at least one member selected from oxides, carbides, nitrides, borides, phosphides, and sulfides of aluminum, iron, titanium, and silicon are dispersed in an amount of 0.01% to 30% based on the entire weight of

the surface coating layer in a matrix consisting of a zinc alloy of 99.7% by weight or less of zinc with 0.3% by weight or more of at least one additional member selected from the group consisting of nickel, cobalt, chromium, iron, and manganese.

13. The zinc-plated steel strip as claimed in claim 12, wherein the amount of the additional metal member selected from nickel, cobalt, chromium, iron, and manganese is in the range of from 0.3% to 80% by weight.

14. The zinc-plated steel strip as claimed in claim 10, wherein the fine dispersoid particles consist of at least one member selected from the group consisting of oxides, carbides, nitrides, borides, phosphides, and sulfides and has an average size of 5 microns or less.

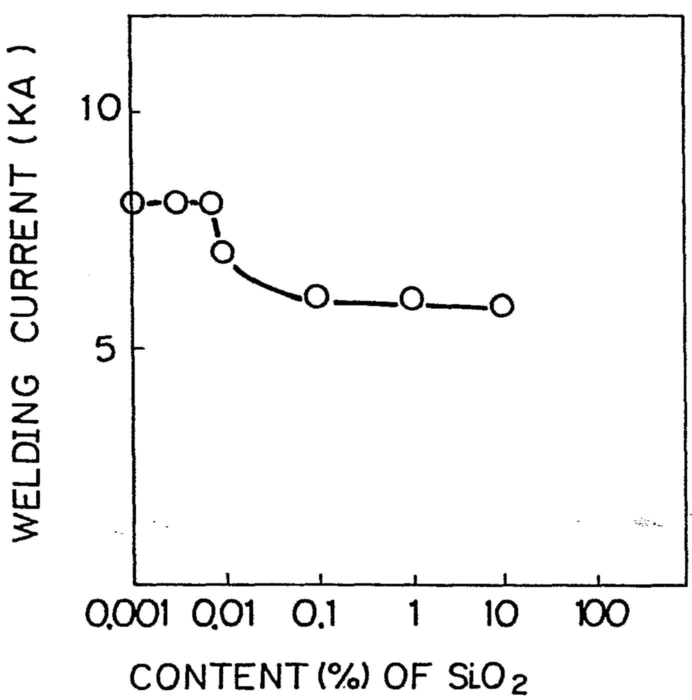
15. The zinc-plated steel strip as claimed in claim 1, wherein the surface coating layer consist essentially of 0.01% to 30% by weight of the fine dispersoid particles consisting of at least one member selected from the group consisting of oxides, carbides, nitrides, borides, phosphides and sulfides of aluminum, iron titanium and silicon and having an average size of 5 microns or less and the balance of the matrix consisting of a zinc alloy consisting of 0.5% to 80% by weight of at least one member selected from the group consisting of nickel, cobalt, chromium, iron and manganese at the balance of zinc.

16. The zinc-plated steel strip as claimed in claim 16, wherein the surface coating layer is formed on an intermediate coating layer consisting of at least one member selectd from the group consisting of zinc and zinc alloys.

17. The zinc-plated steel strip as claimed in claim 5, wherein the surface coating layer has a thickness of from 0.1 to 40 microns and comprises 70% to 99.99% by weight of a matrix consisting of a zinc alloy of 20% to 99.7% by weight of zinc with 0.3% to 80% by weight of at least one additional metal member selected

form nickel, cobalt, chromium, iron, and manganese, and 0.01% to 30% by weight of fine dispersoid particles consisting of silicon oxide and having an average size of 20 millimicrons or less; and the intermediate coating layer has a thickness of from 0.1 to 20 microns and comprises zinc or zinc alloy.

Fig. I



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EUROPEAN SEARCH REPORT

0174019 Application number

EP 85 11 1166

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	21-11-1985	NGUYEN THE NGHIEP

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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