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(54) **Steel wire for automatic coiling and production process thereof.**

(57) A process of producing a steel wire for automatic coiling, said process comprising the steps of: providing Ni plating having a thickness of from 1 to 5 μm to a steel wire containing 0.15% by weight or less of carbon, 1.00% by weight or less of sulfur, 2.00% by weight or less of manganese, 6.50% by weight or more and less than 14% by weight of nickel, and from 17.00 to 20.00% by weight of cromium; coating thereon a synthetic resin containing a halogen; drawing said steel wire to a reduction of cross-sectional area of at least 60%, with adjusting the surface roughness thereof to the range of from 0.8 to 12 s. A steel wire for automatic coiling comprising a steel wire containing 0.15% by weight or less of carbon, 1.00% by weight or less of sulfur, 2.00% by weight or less of manganese, 6.50% by weight or more and less than 14% by weight of nickel, and from 17.00 to 20.00% by weight of cromium, having thereon Ni plating having a thickness of from 0.3 to 1.7 μm and having further coated thereon a synthetic resin containing a halogen, the tensile strength of the wire being at least 160 kgf/mm^2 and the surface roughness thereof being from 0.8 to 12 s.

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FIELD OF THE INVENTION

The present invention relates to a steel wire for automatic coiling and a production process thereof.

BACKGROUND OF THE INVENTION

Hitherto, as a steinless steel wire for automatic coiling, a wire obtained by drawing a stainless steel wire having Ni (nickel) plating on the surface thereof has been used for improving the lubricating property at the drawing step and the subsequent steps such as a coiling step. Such a conventional wire having Ni plating is excellent in various points as compared to a conventional surface-coated wire such as lead-plated wires and wires treated with oxalates.

However, from the present condition of increasing the requirement of the wire having a higher performance, e.g., higher lubricating property for higher coiling speed, the above-mentioned conventional wires do not always sufficiently meet the requirement.

In general, since a stainless steel wire is inferior in the heat conductivity, has a toughness, and shows severe work hardening, the stainless steel wire is inferior to carbon steel wire in workability upon drawing and workability in the subsequent steps. Accordingly, the stainless steel wire has disadvantages in that the lubricating property upon drawing is insufficient, the working speed in the subsequent step (e.g., a coiling step) is insufficient, and there is difficulties in constantly obtaining products having a uniform shape.

SUMMARY OF THE INVENTION

An object of the present invention is to provide a process for producing a steel wire for automatic coiling which has an excellent lubricating property in a drawing step and subsequent steps.

Another object of the present invention is to provide a steel wire for automatic coiling haivng an excellent lubricating property in a drawing step and subsequent steps.

Other objects and effects of the present invention will be apparent from the following description.

The present invention relates to a process of producing a steel wire for automatic coiling, said process comprising the steps of:

providing Ni plating having a thickness of from 1 to 5 μm to a steel wire containing
0.15% by weight or less of carbon,
1.00% by weight or less of sulfur,
2.00% by weight or less of manganese,
6.50% by weight or more and less than 14% by
weight of nickel, and
from 17.00 to 20.00% by weight of cromium;
coating thereon a synthetic resin containing a halogen;
drawing the steel wire to a reduction of cross-sectional area of at least 60%, with adjusting the surface roughness thereof to the range of from 0.8 to 12 s.

The present invention also relates to a steel wire for automatic coiling comprising a steel wire containing
0.15% by weight or less of carbon,
1.00% by weight or less of sulfur,
2.00% by weight or less of manganese,
6.50% by weight or more and less than 14% by weight of nickel, and
from 17.00 to 20.00% by weight of cromium,
having thereon Ni plating having a thickness of from 0.3 to 1.7 μm and having further coated thereon a synthetic resin containing a halogen, the tensile strength of the wire being at least 160 kgf/mm^2 and the surface roughness thereof being from 0.8 to 12 s.

DETAILED DESCRIPTION OF THE INVENTION

In the present invention, the surface roughness of the steel wire after the final drawing is from 0.8 s (0.6 to 0.9 μm) to 12 s (9 to 15 μm) according to JIS B601 and B659. In order to attain the surface roughness of the wire after drawing, it is necessary to appropriately control the surface roughness of the starting wire and the plating conditions (composition and pH of plating solution, temperatue, electrical curreant, stirring, etc.).

The thicness of the Ni plating before drawing is from 1 to 5 μm, and preferably about 3 μm. If it is too thick, the strength of the wire is reduced.

Examples of the synthetic resin containing a halogen include polyethylene chloride, polytrifluorochloroethylene and polytetrafluoroethylene. The method for coating the synthetic resin on the wire is not particularly limited, and a dip coating method is preferably employed because of easiness of operation. The thickness of the synthetic resin coated layer is preferably from 0.1 to 1 μm after drawing.

A dies used for drawing the wire is not particularly limited, and examples thereof include WC alloy dies, diamond dies and sintered diamond dies, each having a dies angle of from 12 to 15°. The conditions of drawing are not particularly limited as long as the reduction of cross-sectional area is at least 60%, preferably from 75 to 85%, with adjusting the surface roughness thereof is in the range of from 0.8 to 12 s. For example, when the diameter of the finishing die is 1 mm, the drawing speed is generally from 300 to 1,000 m/min.

A lubricant is generally used when the wire drawn. A lubricant mainly composed of calcium stearate containing molybdenum disulfide and lime is generally used as a lubricant.

The thickness of te Ni plating after drawing, i.e., that of the steel wire for automatic coiling of the present invention, is from 0.3 to 1.7 μm, and preferably about 1 μm.

Since the steel wire of the present invention is used for a spring, it is necessary that the tensile strength thereof is at least 160 kgf/mm^2.

According to the production process of the present invention, there are the following advantages:

(1) Since the friction resistance between a die and the wire upon drawing is reduced, the drawing speed can be increased.

(2) Since a lubricant enters the concaved portions of the surface of the wire having the specific surface roughness to increase the lubricating performance, seizing upon drawing can be reduced to prolong the life of the die.

By using the wire of the present invention to produce a spring, there are the following advantages:

(3) Since the friction resistance between a bending die and the wire can be reduced, and a lubricant enters the concaved portions of the surface of the wire, the lubricating property is inreased, whereby the coiling speed can be increased.

(4) Springs having a uniform shape, such as free length, can be constantly obtained.

The present invention will be described in more detail by referring to the following examples, reference examples and comparative examples, but the present invention is not construed as being limited to the examples.

EXAMPLES

The stainless steel wires used were ATST 304, 316, and 631 and the compositions thereof are shown in Table 1 below. The content of the ingredient in Table 1 are shown in terms of percent by weight. The balance was iron.

TABLE 1

Stainless steel (ATST)	C	Si	Mn	P	S	Ni	Cr	Mo
304	0.077	0.52	1.27	0.025	0.010	8.55	18.58	0.02
316	0.065	0.62	1.22	0.021	0.008	11.02	16.98	2.31
631	0.089	0.50	0.83	0.018	0.007	7.06	16.84	0.01

The Ni plating and a synthetic resin coating is provided on each of the steel wires to provide each test sample having a diameter of 2.3 mm. In Sample D (Comparative Example) was obtained by applying electrolytic polishing to the steel wire after providing Ni plating to reduce the surface roughness.

TABLE 2

Sample	Stainless steel (ATST)	Ni-plating thickness (μm)	Ni-plating surface roughness (s)	Synthetic resin coating
A	304	3.0	12	none
B	304	none	-	PEC
C	304	none	-	PTFE
D	304	2.9	1.5	PTFE
E	304	3.2	50	PTFE
F	304	3.0	12	PEC
G	304	3.4	6	PTFE
H	304	3.0	35	PFCE
I	304	4.5	12	PTFE
J	304	1.2	12	PTFE
K	316	3.0	12	PTFE
L	631	3.0	12	PTFE
M	304	0.5	12	PTFE
N	304	8	12	PTFE

Note:
Samples A, B, and C: Reference Examples
Samples D, E, M, and N: Comparative Examples
Samples F to L: Samples of the invention
PEC: Polyethylene chloride
PTFE: Polytetrafluoroethylene
PFCE: Polytrifluorochloroethylene

Each sample was drawn to a wire having a diameter of 1.0 mm and the life of the final die and the surface roughness of the wire after drawing were determined.

The drawing was carried out by a straight type continuous wire drawing machine using alloy dies and a calcium stearate lubricant.

The life of the die shown in Table 3 was the life of the final die at the drawing speed of 400 m/min.

The results obtained are shown in Table 3.

TABLE 3

Sample	Life of die (ton)	Surface roughness after drawing (s)	Ni-plating thickness after drawing (μm)
A	6.9	3	1.1
B	6.2	3	-
C	5.8	3	-
D	1.8	0.4	1.1
E	8.2	25	1.3
F	10.2	3	1.2
G	13.5	1.5	1.3
H	14.2	12	1.2
I	11.5	3	1.9
J	9.8	3	0.5
K	12.5	3	1.2
L	9.7	3	1.2
M	6.8	3	0.15
N	13.5	3	2.8

Note:
Samples A, B, and C: Reference Examples
Samples D, E, M, and N: Comparative Examples
Samples F to L: Samples of the invention

As shown in Table 3, it is understood that the lives of the dies in the drawing step according to the process of the present invention are longer than those in the conventional examples each having only the Ni-plated layer or only the synthetic resin coated layer.

In Sample D (Comparative Example) in which the surface roughness was very fine, since the lubricant was difficult to be maintained on the surface of the wire, siezing was liable to occur and the life of the die was very short.

In Sample E (Comparative Example), the surface was greatly roughened after the wire elongation and hence the steel wire is unsuitable in appearance for use as a high quality stainless steel material.

In Sample M (Comparative Example), although the effect of improving the life of the die was attained, since the thickness of plating was thin, the stainless steel was partially exposed after drawing.

Springs were produced with each of the wires subjected to the foregoing drawing except Sample E (Comparative Example) by using an automatic coiling machine. Sample E could not be used for producing a spring because of the exposure of the base stainless steel. The specification of the spring was as follows:

Wire Diameter: 1.0 mm
Coil Central Diameter: 10.0 mm
Total Coiled Number: 8.5
Effective Coiled Number: 7.5
Free Strength: 40.0 mm

Upon producing springs, the Ni plating of Sample N (Comparative Example) was peeled off because of its large thickness, and the production of springs was thus terminated.

300 springs were prepared from each of the samples except for Samples E and N using a precise automatic coiling machine and then the average of the free lengths and the standard deviation were determined. The results obtained are shown in Table 4 below.

TABLE 4

Sample	Average free length (mm)	Standard deviation
A	40.035	0.171
B	40.038	0.217
C	40.011	0.189
D	40.012	0.329
E	-	-
F	40.007	0.126
G	40.004	0.120
H	40.005	0.126
I	40.006	0.120
J	40.010	0.133
K	40.065	0.118
L	40.001	0.135
M	40.010	0.157
N	-	-

Note:
Samples A, B, and C: Reference Examples
Samples D, E, M, and N: Comparative Examples
Samples F to L: Samples of the invention

As is clear from the the results shown in Table 4, it is understood that the springs produced by using the wires of the present invention showed less dispersion in free length.

The ratio of the actual free length to the target free length of a spring is called "free length ratio" and the quality of a spring is determined by the free length ratio of the spring. In general, the free length ratio is allowable ± 0.1% for a precise spring and ± 0.05% for a super precise spring. The percent defective of the above-produced springs for precise spring and super precise spring are shown in Table 5.

TABLE 5

Sample	Percent defective (%)	
	Precise spring (± 0.1%)	Super precice spring (± 0.05%)
A	1	14
B	2	20
C	2	15
D	18	44
E	-	-
F	0	4
G	0	4
H	0	4
I	0	4
J	0	5
K	0	3
L	0	6
M	1	11
N	-	-

Note:
Samples A, B, and C: Reference Examples
Samples D, E, M, and N: Comparative Examples
Samples F to L: Samples of the invention

As shown in Table 5, it is understood that the samples according to the present invention showed the very low percent defective as compared with the samples of the comparative examples and the reference examples.

As described above, according to the process of the present invention, the friction resistance between a die and the wire upon drawing can be reduced and the life of the die can be prolonged. By using the wire of the present invention, since the friction resistance between a bending die and the wire can be reduced, and a lubricant enters the concaved portions on the surface of the wire, the lubricating property of the wire is increased and the coiling speed can be increased. Furthermore, springs having a uniform shape, such as free length, can constantly obtained.

While the invention has been described in detail and with reference to specific examples thereof, it will be apparent to one skilled in the art that various changes and modifications can be made therein without departing from the spirit and scope thereof.

Claims

1. A process of producing a steel wire for automatic coiling, said process comprising the steps of:
providing Ni plating having a thickness of from 1 to 5 μm to a steel wire containing
0.15% by weight or less of carbon,
1.00% by weight or less of sulfur,
2.00% by weight or less of manganese,
6.50% by weight or more and less than 14% by weight of nickel, and
from 17.00 to 20.00% by weight of cromium;
coating thereon a synthetic resin containing a halogen;
drawing said steel wire to a reduction of cross-sectional area of at least 60%, with adjusting the surface roughness thereof to the range of from 0.8 to 12 s.

2. A steel wire for automatic coiling comprising a steel wire containing
0.15% by weight or less of carbon,
1.00% by weight or less of sulfur,
2.00% by weight or less of manganese,
6.50% by weight or more and less than 14% by weight of nickel, and
from 17.00 to 0.00% by weight of cromium,
having thereon Ni plating having a thickness of from 0.3 to 1.7 μm and having further coated thereon a synthetic resin containing a halogen, the tensile strength of said wire being at least 160 kgf/mm^2 and the surface roughness thereof being from 0.8 to 12 s.

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EUROPEAN SEARCH REPORT

Application Number EP 93107018.9

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.5)
A	CHEMICAL ABSTRACTS, vol. 117, no. 8, August 24, 1992, Columbus, Ohio, USA NISHIMURA,T. "Manufacture of stainless steel wire suitable for coil springs" page 267; & Jpn. Kokai Tokkyo Koho JP-A-04-17 616 (92-17 616) * Column 1, abstract-no. 74 095r * --	1,2	C 25 D 7/06
A	CHEMICAL ABSTRACTS, vol. 115, no. 26, December 30, 1991, Columbus, Ohio, USA KOBE STEEL LTD. "Nickel-electroplated steel wire for miniature coil springs" page 288; & Jpn. Kokai Tokkyo Koho JP-A-03-51 537 (91-51 537) * Column 2, abstract-no. 284 585k * --	1,2	TECHNICAL FIELDS SEARCHED (Int. Cl.5) C 25 D 7/00
A	CHEMICAL ABSTRACTS, vol. 107, no. 18, November 2, 1987, Columbus, Ohio, USA TOTOKU ELECTRIC CO. "Manufacture of insulation wires for high frequency coils" page 119; & Jpn. Kokai Tokkyo Koho JP-A-62-151 594 (87-151 594) * Column 2, abstract-no. 156 436k * ----	1,2	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
VIENNA	19-04-1994	BRUS

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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