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(54) Titre : TOLE D'ACIER LAMINEE A FROID ET REVETUE ET SON PROCEDE DE FABRICATION
(54) Title: COLD ROLLED AND COATED STEEL SHEET AND A METHOD OF MANUFACTURING THEREOF

(57) Abrégé/Abstract:
A cold rolled and coated steel sheet having a composition comprising of the following elements, 0.12%≤Carbon≤0.2%, 1.7%≤Manganese≤2.10%, 0.1% ≤Silicon≤ 0.5 %, 0.1%≤Aluminum≤ 0.8%, 0.1% ≤ Chromium ≤ 0.5 %, 0 % ≤ Phosphorus ≤ 0.09 %, 0 % ≤ Sulfur ≤ 0.09 %, 0 % ≤ Nitrogen ≤ 0.09%, Nickel ≤ 3%, Niobium ≤ 0.1%, Titanium ≤0.1%, Calcium≤0.005%, Copper≤2%, Molybdenum≤0.5%, Vanadium≤0.1%, Boron≤0.003%, Cerium≤0.1%, Magnesium ≤ 0.010%, Zirconium≤0.010% the remainder composition being composed of iron and unavoidable impurities caused by processing, the microstructure of said steel sheet comprising in area fraction, 10 to 60% Bainite, 25 to 55% Ferrite, 5% to 15% Residual Austenite wherein carbon content in residual austenite is between 0.7% and 1% and 5% to 18% Martensite, wherein the cumulated amount of Bainite and Ferrite is at least 70%.

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(57) Abstract: A cold rolled and coated steel sheet having a composition comprising of the following elements, 0.12%≤Carbon≤0.2%, 1.7%≤Manganese≤2.10%, 0.1% ≤Silicon≤ 0.5 %, 0.1%≤Aluminum≤ 0.8%, 0.1% ≤ Chromium ≤ 0.5 %, 0 % ≤ Phosphorus ≤ 0.09 %, 0 % ≤ Sulfur ≤ 0.09 %, 0 % ≤ Nitrogen ≤ 0.09%, Nickel ≤ 3%, Niobium ≤ 0.1%, Titanium ≤0.1%, Calcium≤0.005%, Copper≤2%, Molybdenum≤0.5%, Vanadium≤0.1%, Boron≤0.003%, Cerium≤0.1%, Magnesium ≤ 0.010%, Zirconium≤0.010% the remainder composition being composed of iron and unavoidable impurities caused by processing, the microstructure of said steel sheet comprising in area fraction, 10 to 60% Bainite, 25 to 55% Ferrite, 5% to 15% Residual Austenite wherein carbon content in residual austenite is between 0.7% and 1% and 5% to 18% Martensite, wherein the cumulated amount of Bainite and Ferrite is at least 70%.

COLD ROLLED AND COATED STEEL SHEET AND A METHOD OF MANUFACTURING THEREOF

The present invention relates to cold rolled coated steel sheets suitable for use as steel sheet for automobiles.

Automotive parts are required to satisfy two inconsistent necessities, viz. ease of forming and strength but in recent years a third requirement of improvement in fuel consumption is also bestowed upon automobiles in view of global environment concerns. Thus, now automotive parts must be made of material having high formability in order that to fit in the criteria of ease of fit in the intricate automobile assembly and at same time have to improve strength for vehicle crashworthiness and durability while reducing weight of vehicle to improve fuel efficiency.

Therefore, intense Research and development endeavors are put in to reduce the amount of material utilized in car by increasing the strength of material. Conversely, an increase in strength of steel sheets decreases formability, and thus development of materials having both high strength and high formability is necessitated.

Earlier research and developments in the field of high strength and high formability steel sheets have resulted in several methods for producing high strength and high formability steel sheets, some of which are enumerated herein for conclusive appreciation of the present invention:

EP2768989 claims to have a high strength hot dip galvanised steel strip consisting, in mass percent, of the following elements 0.13 - 0.19 % C,1.70 - 2.50 % Mn, max 0.15 % Si, 0.40 - 1.00 % Al, 0.05 - 0.25 % Cr, 0.01 - 0.05 % Nb, Max 0.10 % P,max 0.004 % Ca, max 0.05 % S, max 0.007 % N,and optionally at least one of the following elements max 0.50 % Ti, max 0.40 % V,max 0.50 % Mo, max 0.50 % Ni, max 0.50 % Cu, max 0.005 % B,the balance being Fe and inevitable impurities, wherein 0.40 % < Al + Sl < 1.05 % and Mn + Cr > 1.90 %, wherein the hot dip galvanised steel strip has a microstructure containing 8 - 12 % retained austenite, 10 - 20 % martensite, the remainder being a mixture of ferrite and bainite, the hot dip galvanised steel strip containing not more than 10 % bainite, and wherein the hot dip galvanised steel strip has an ultimate tensile strength Rm of at least 700 MPa, an 0.2 % proof strength Rp

of at least 400 MPa and a total elongation of at least 18 %.The Steel of EP2768989 do not foresee a steel with strength of 780MPa or more while preferring elongation above 20%.

The purpose of the present invention is to solve these problems by making available cold-rolled steel sheets that simultaneously have:

- an ultimate tensile strength greater than or equal to 780 MPa and preferably above 800 MPa,
- a total elongation greater than or equal to 18% and preferably above 20%.

Preferably, such steel can also have a good suitability for forming, for rolling with good weldability and coatability.

Another object of the present invention is also to make available a method for the manufacturing of these sheets that is compatible with conventional industrial applications while being robust towards manufacturing parameters shifts.

The cold rolled and heat treated steel sheet of the present invention is be coated with zinc or zinc alloys, or with aluminium or aluminium alloys to improve its corrosion resistance.

Carbon is present in the steel between 0.12% and 0.2%. Carbon is an element necessary for increasing the strength of the steel sheet by producing low-temperature transformation phases such as martensite and bainite, further Carbon also plays a pivotal role in Austenite stabilization hence a necessary element for securing Residual Austenite. Therefore, Carbon plays two pivotal roles one in increasing the strength and another in retaining austenite to impart ductility. But Carbon content less than 0.12% will not be able to stabilize Austenite in an adequate amount required by the steel of present invention. On the other hand, at a Carbon content exceeding 0.2%, the steel exhibits poor spot weldability which limits its application for the automotive parts. The preferred range for carbon for the steel of present invention is 0.12% to 0.19% and more preferably 0.14% to 0.18%.

Manganese content of the steel of present invention is between 1.7 % and 2.10%. This element is gammagenous. The purpose of adding Manganese is essentially to obtain a structure that contains Austenite and impart strength to the steel. An amount of at least 1.7% by weight of Manganese has been found to provide the strength and hardenability of the steel sheet as well as to stabilize Austenite. In addition the Manganese content of above 2.10% also reduces the ductility and also deteriorates the weldability of the present steel hence the elongation targets may not be achieved. A preferable content for the present invention may be kept between 1.7% and 2.08%, furthermore preferably 1.8% and 2.08%.

In a preferred embodiment, the cumulative amount of Carbon and Manganese is kept between 2.1% and 2.25% to secure an even increased amount of retained austenite.

Silicon content of the steel of present invention is between 0.1% and 0.5%. Silicon is a constituent that can retard the precipitation of carbides during overageing, therefore, due to the presence of Silicon, carbon rich Austenite is stabilized at room temperature However, disproportionate content of Silicon does not produce the mentioned effect and leads to a problem such as temper embrittlement. Therefore, the concentration is controlled within an upper limit of 0.5%. A preferable content for the present invention may be kept between 0.1% and 0.4%

Aluminum is an essential element and is present in the steel of present invention between 0.1% and 0.8%. Aluminum promotes ferrite formation and increases the Ms temperature which allows the present invention to have both Martensite and Ferrite in adequate amount as required by the. steel of present invention to impart steel of present invention with ductility as well as strength. However, when the presence of Aluminum is more than 0.8% increases the Ac3 temperature which makes the annealing and hot rolling finishing temperature in complete Austenitic region economically unreasonable. The Aluminum content is preferably limited between 0.2% and 0.8% and more preferably 0.3% and 0.6%.

The cumulative amount of Silicon and Aluminium is preferably between 0.5% and 0.9% and more preferably between 0.6% and 0.9%, to increase further the amount of retained austenite.

Chromium is an essential element for the present invention. Chromium content is present in the steel of present invention between 0.1% and 0.5%. Chromium provides strength and hardening to the steel but when used above 0.5% it impairs surface finish of steel. The preferred limit for Chromium for the present invention is between 0.1% and 0.4% and more preferably 0.2% and 0.4%.

Phosphorus is not an essential element but may be contained as an impurity in steel and from the point of view of the present invention the phosphorus content is preferably as low as possible, and below 0.09%. Phosphorus reduces the spot weldability and the hot ductility, particularly due to its tendency to segregate at the grain boundaries or co-segregate with manganese. For these reasons, its content is limited to less than 0.09, preferably less than 0.3 % and more preferably less than 0.014%.

Sulfur is not an essential element but may be contained as an impurity in steel and from the point of view of the present invention the Sulfur content is preferably as low as possible, but is 0.09% or less from the viewpoint of manufacturing cost. Further if higher Sulfur is present in steel it combines to form Sulfides especially with Manganese and reduces its beneficial impact on the steel of present invention.

Nitrogen is limited to 0.09% to avoid ageing of material and to minimize the precipitation of nitrides during solidification which are detrimental for mechanical properties of the Steel.

Nickel may be added as an optional element in an amount up to 3% to increase the strength of the steel and to improve its toughness. A minimum of 0.01% is preferred to produce such effects. However, when its content is above 3%, Nickel causes ductility deterioration.

Niobium is an optional element for the present invention. Niobium content may be present in the steel of present invention up to 0.1% and is added in the Steel of present invention for forming carbo-nitrides to impart strength of the Steel of present invention by precipitation hardening. Niobium will also impact the size of microstructural components through its precipitation as carbo-nitrides and by retarding the recrystallization during heating process. Thus finer microstructure formed at the end of

the holding temperature and as a consequence after the completion of annealing that will lead to the hardening of the Steel of present invention. However, Niobium content above 0.1% is not economically interesting as a saturation effect of its influence is observed this means that additional amount of Niobium does not result in any strength improvement of the product.

Titanium is an optional element and may be added to the Steel of present invention up to 0.1%. As Niobium, it is involved in carbo-nitrides formation so plays a role in hardening of the Steel of present invention. In addition, Titanium also forms Titanium-nitrides which appear during solidification of the cast product. The amount of Titanium is so limited to 0.1% to avoid formation of coarse Titanium-nitrides detrimental for formability. In case the Titanium content is below 0.001% it does not impart any effect on the steel of present invention.

Calcium content in the steel of present invention is up to 0.005%. Calcium is added to steel of present invention as an optional element especially during the inclusion treatment with a preferred minimum amount of 0.0001%. Calcium contributes towards the refining of Steel by arresting the detrimental Sulfur content in globular form, thereby, retarding the harmful effects of Sulfur.

Copper may be added as an optional element in an amount up to 2% to increase the strength of the steel and to improve its corrosion resistance. A minimum of 0.01% of Copper is preferred to get such effect. However, when its content is above 2%, it can degrade the surface aspects.

Molybdenum is an optional element that constitutes up to 0.5% of the Steel of present invention; Molybdenum plays an effective role in determining hardenability and hardness, delays the appearance of Bainite and avoids carbides precipitation in Bainite. However, the addition of Molybdenum excessively increases the cost of the addition of alloy elements, so that for economic reasons its content is limited to 0.5%.

Vanadium is effective in enhancing the strength of steel by forming carbides or carbo-nitrides and the upper limit is 0.1% due to the economic reasons. Other elements such as Cerium, Boron, Magnesium or Zirconium can be added individually or in combination in the following proportions by weight: Cerium $\leqq$0.1%, Boron $\leqq$ 0.003%, Magnesium $\leqq$ 0.010% and Zirconium $\leqq$ 0.010%. Up to the maximum content levels

indicated, these elements make it possible to refine the grain during solidification. The remainder of the composition of the Steel consists of iron and inevitable impurities resulting from processing.

The microstructure of the Steel sheet will now be described.

Bainite constitutes from 10% to 60% of microstructure by area fraction for the steel of the invention. Bainite can be under the form of upper bainite and/ or lower bainite. Bainite may be formed during over-aging holding. Bainite impart strength to the steel of present invention. To achieve the tensile strength of 780MPa or more it is necessary to have 10% bainite. The preferred range for the presence of bainite according to the present invention is between 20% and 60% and more preferably between 30% and 55%.

Ferrite constitutes from 25% to 55% of microstructure by area fraction for the Steel of present invention. Ferrite imparts high strength as well as elongation to the steel of present invention. To ensure an elongation of 18% and preferably 20% or more it is necessary to have 25% of Ferrite. Ferrite of the present invention is formed during annealing and cooling done after annealing. But whenever ferrite content is present above 55% in steel of present invention it is not possible to have both tensile strength and the total elongation at same time. The preferred limit for presence of ferrite for the present invention is between 30% and 55% and more preferably 30% and 50%.

The cumulated amount of ferrite and bainite is at least 70%, this cumulative amount of Ferrite and Bainite ensures that the steel of present invention always have a total elongation above 18%. This cumulative presence also ensures that the presence of ferrite above 30% to have enough soft phase in the steel of present invention ti impart formability to the steel of present invention.

Residual Austenite constitutes from 5% to 15% by area fraction of the Steel. Residual Austenite is known to have a higher solubility of Carbon than Bainite and, hence, acts as effective Carbon trap, therefore, retarding the formation of carbides in Bainite. Carbon percentage inside the Residual Austenite of present invention is higher than 0.7% and lower than 1%. Residual Austenite of the Steel according to the invention imparts an enhanced ductility. However, when the Carbon content of Residual

Austenite is below 0.7%, it will not able to trap enough carbon and will lead to formation of excess martensite instead of adequate amount of bainite, this effect provides excess strength to the steel and is also detrimental to elongation. The preferable limit of for the presence of Austenite is between 6% and 15% wherein the preferable Carbon content limit in austenite is preferred between 0.7% and 0.9% and more preferably between 0.7% and 0.8%.

Martensite constitutes between 5% and 18% of microstructure by area fraction. Martensite for present invention includes both fresh martensite and tempered martensite. Present invention form martensite due to the cooling after annealing and get tempered during overaging holding. Fresh Martensite also form during cooling after the coating of cold rolled steel sheet. Martensite imparts ductility and strength to the Steel of present invention. However, when martensite presence is above 18%. it imparts excess strength but diminishes the elongation beyond acceptable limit for the steel of present invention. Preferred limit for martensite for the steel of present invention is between 5% and 15%.

In addition to the above-mentioned microstructure, the microstructure of the cold rolled and heat treated steel sheet is free from microstructural components, such as pearlite and cementite without impairing the mechanical properties of the steel sheets.

A steel sheet according to the invention can be produced by any suitable method. A preferred method consists in providing a semi-finished casting of steel with a chemical composition according to the invention. The casting can be done either into ingots or continuously in form of thin slabs or thin strips, i.e. with a thickness ranging from approximately 220mm for slabs up to several tens of millimeters for thin strip.

For example, a slab having the above-described chemical composition is manufactured by continuous casting wherein the slab optionally underwent the direct soft reduction during the continuous casting process to avoid central segregation and to ensure a ratio of local Carbon to nominal Carbon kept below 1.10. The slab provided by continuous casting process can be used directly at a high temperature after the continuous casting or may be first cooled to room temperature and then reheated for hot rolling.

The temperature of the slab, which is subjected to hot rolling, is at least 1000° C and must be below 1280°C. In case the temperature of the slab is lower than 1000° C, excessive load is imposed on a rolling mill and, further, the temperature of the steel may decrease to a Ferrite transformation temperature during finishing rolling, whereby the steel will be rolled in a state in which transformed Ferrite contained in the structure. Therefore, the temperature of the slab is preferably sufficiently high so that hot rolling can be completed in the temperature range of Ac3 to Ac3+100°C and final rolling temperature remains above Ac3. Reheating at temperatures above 1280°C must be avoided because they are industrially expensive.

A final rolling temperature range between Ac3 to Ac3+100°C is necessary to have a structure that is favorable to recrystallization and rolling. It is preferred that the final rolling pass to be performed at a temperature greater than 850°C, because below this temperature the steel sheet exhibits a significant drop in rollability. The hot rolled steel obtained in this manner is then cooled at a cooling rate above 30°C/s to the coiling temperature which must be between 475°C and 650°C. Preferably, the cooling rate will be less than or equal to 200° C/s.

The hot rolled steel is then coiled at a coiling temperature between 475°C and 650°C to avoid ovalization and preferably between 475°C and 625°C to avoid scale formation. A more preferred range for such coiling temperature is between 500°C and 625°C. The coiled hot rolled steel is cooled down to room temperature before subjecting it to optional hot band annealing.

The hot rolled steel may be subjected to an optional scale removal step to remove the scale formed during the hot rolling before optional hot band annealing. The hot rolled sheet may then subjected to an optional Hot Band Annealing at, for example, temperatures between 400°C and 750°C for at least 12 hours and not more than 96 hours, the temperature remaining below 750°C to avoid transforming partially the hot-rolled microstructure and, therefore, losing the microstructure homogeneity. Thereafter, an optional scale removal step of this hot rolled steel may performed through, for example, pickling of such sheet. This hot rolled steel is subjected to cold rolling to obtain a cold rolled steel sheet with a thickness reduction between 35 to 90%. The cold rolled steel sheet obtained from cold rolling process is then subjected to

annealing to impart the steel of present invention with microstructure and mechanical properties.

Annealing the said cold rolled steel sheet in two steps heating wherein the first step starts from heating the steel sheet from room temperature to a temperature T1 between 600°C and 750°C, with a heating rate HR1 of at least 3°C/s, thereafter the second step starts from heating further the steel sheet from T1 to a soaking temperature T2 between Ac1 and Ac3, with a heating rate HR2 of 15°C/s or less, HR2 being lower than HR1,then perform annealing at T2 during 10 to 500 seconds. In a preferred embodiment, the heating rate for the second step the heating rate is less than 10°C/s and more preferably less than 5°C/s. The preferred temperature T2 for soaking is between Ac1 +30°C and Ac3.

Then the cold rolled steel sheet is annealed at soaking temperature T2 between Ac1 and Ac3 wherein Ac1 and Ac3 for the present steel is calculated by using the following formula:

$$Ac1 = 723 - 10{,}7[Mn] - 16[Ni] + 29{,}1[Si] + 16{,}9[Cr] + 6{,}38[W] + 290[As]$$

$$Ac3 = 955 - 350C - 25Mn + 51Si + 106Nb + 100Ti + 68Al - 11Cr - 33Ni - 16Cu + 67Mo$$

wherein the elements contents are expressed in weight percent.

Then the cold rolled steel sheet is held at the soaking temperature T2 during 10 to 500 seconds. In a preferred embodiment, the time and temperature of soaking are selected so as to ensure that the microstructure of the steel sheet at the end of the soaking contains at least 60% of Austenite and more preferably at least 70% of austenite.

Then the cold rolled steel is cooled from T2 to an overaging holding temperature Tover between 375°C and 480°C, preferably between 380°C and 460°C, at an average cooling rate of at least 10°C/s and preferably at least 15°C/s, wherein the cooling step may include an optional slow cooling sub-step between T2 and a temperature Tsc between 600°C and 750°C,with a cooling rate of 2°C/s or less and preferably of 1°C/s or less.

The cold rolled steel sheet is then held at Tover during 5 to 500 seconds.

The cold rolled steel sheet can then be brought to the temperature of the coating bath between 420°C and 460°C, depending on the nature of the coating, to facilitate hot dip coating of the cold rolled steel sheet.

The cold rolled steel sheet can also be coated by any of the known industrial processes such as Electro-galvanization, JVD, PVD, etc, which may not require bringing it to the above mentioned temperature range before coating.

Then an optional post batch annealing may be done at a temperature between 150°C and 300°C during 30 minutes to 120 hours.

EXAMPLES

The following tests, examples, figurative exemplification and tables which are presented herein are non-restricting in nature and must be considered for purposes of illustration only, and will display the advantageous features of the present invention.

Steel sheets made of steels with different compositions are gathered in Table 1, where the steel sheets are produced according to process parameters as stipulated in Table 2, respectively. Thereafter Table 3 gathers the microstructures of the steel sheets obtained during the trials and table 4 gathers the result of evaluations of obtained properties.

Table 1

Trials	C	Mn	Si	Al	Cr	Nb	P	S
A	0.161	2.00	0.25	0.53	0.21	0	0.003	0.0012
B	0.168	2.00	0.25	0.50	0.22	0	0.008	0.0014
C	0.173	2.06	0.25	0.59	0.25	0	0.010	0.0011
D	0.173	2.06	0.25	0.59	0.25	0	0.010	0.0012
E	0.173	2.06	0.25	0.59	0.25	0	0.010	0.0013
F	0.178	2.00	0.24	0.49	0.22	0	0.012	0.0012
G	0.172	1.99	0.25	0.52	0.21	0	0.012	0.0011
H	0.170	2.00	0.25	0.55	0.21	0	0.011	0.0010
I	0.161	2.15	0.25	0.72	0.20	0.0019	0.003	0.0012
J	0.161	2.15	0.25	0.53	0.20	0.0019	0.003	0.0013
K	0.168	2.21	0.27	0.62	0.23	0	0.009	0.0011

underlined values: not according to the invention.

Table 2

Table 2 gathers the annealing process parameters implemented on steels of Table 1. The Steel compositions A to G serve for the manufacture of sheets according to the invention. Table 2 also shows tabulation of Ac1 and Ac3. These Ac1 and Ac3 are defined for the inventive steels and reference steels as follows:

$$Ac1 = 723 - 10,7[Mn] - 16[Ni] + 29,1[Si] + 16,9[Cr] + 6,38[W] + 290[As]$$

$$Ac3 = 955 - 350C - 25Mn + 51Si + 106Nb + 100Ti + 68Al - 11Cr - 33Ni - 16Cu + 67Mo$$

wherein the elements contents are expressed in weight percent.

Following processing parameters are same for all the steels of Table 1. All steels of table 1 are heated to a temperature of 1200°C before hot rolling. The cold rolling reduction for all the steels is 60% and they were finally brought at a temperature of 460°C before zinc hot dip coating.

The table 2 is as follows:

Table 2

		Hot Rolling			Annealing									Overaging			
Trials	Steel	Finish T(°C)	Cooling rate after Hot Rolling (°C/s)	Coiling T(°C)	HR1 (°C/s)	T1 (°C)	HR2 (°C/s)	T2	Soaking time	Slow cooling rate after annealing (°C/s)	Tsc (°C)	Average cooling rate (°C/s)	cooling stop temperature (°C)	Tover (°C)	time (s)	Ac3 (°C)	Ac1 (°C)
I1	A	920	110	570	6	720	1.9	840	60	NO	NO	27	470	470	27	895	712
I2	B	920	110	570	4.7	705	1.5	830	73	NO	NO	21	470	470	33	891	712
I3	C	920	110	570	18.9	720	0.8	840	390	NO	NO	31	440	440	150	893	712
I4	D	920	110	570	28.3	720	1.3	820	260	NO	NO	48	420	420	95	893	712
I5	E	920	110	570	18.9	720	0.8	840	238	0.6	700	25	420	420	150	893	712
I6	F	920	110	570	20.3	690	1.2	840	334	NO	NO	35.4	440	440	125	886	712
I7	G	920	110	570	3.9	690	1.2	820	88	NO	NO	17.3	470	470	40	891	713
R1	H	890	120	425	3.9	705	1.2	825	90	NO	NO	17	460	460	40	893	712
R2	I	920	110	570	3.8	680	1.2	800	90	NO	NO	16	460	460	40	904	712
R3	J	920	110	570	3.8	680	1.2	800	90	NO	NO	16	460	460	40	892	712
R4	K	920	110	570	5.9	705	1.9	825	60	NO	NO	26	470	470	27	894	712

I = according to the invention; R = reference; underlined values: not according to the invention.

Table 3

Table 3 exemplifies the results of the tests conducted in accordance with the standards on different microscopes such as Scanning Electron Microscope for determining the microstructures of both the inventive and reference steels.

The results are stipulated herein:

Trials	Ferrite	Bainite	Residual Austenite	Martensite	C content RA (%)	Ferrite +Bainite
I1	45.1	32.9	12.0	10.0	0.76	78.0
I2	36.8	41.2	9.3	12.7	0.70	78.0
I3	35.7	41.3	11.8	11.2	0.75	77.0
I4	45.9	29.1	*12.2*	12.8	0.74	75.0
I5	36.0	38.0	12.1	13.9	0.71	74.0
I6	32.3	43.7	11.7	12.3	0.72	76.0
I7	41.0	36.0	*9.4*	13.6	0.73	77.0
R1	23.0	43.0	8.6	24.4	0.60	66.0
R2	57.0	5.0	13.7	24.3	0.63	62.0
R3	58.0	7.0	14.1	20.9	0.63	65.0
R4	21.6	44.2	8.3	25.9	0.62	65.8

I = according to the invention; R = reference; underlined values: not according to the invention.

Table 4

Table 4 exemplifies the mechanical properties of both the inventive steel and reference steels. In order to determine the tensile strength, yield strength and total elongation, tensile tests are conducted in accordance of JIS Z2241 standards.

The results of the various mechanical tests conducted in accordance to the standards are gathered

Table 4

Trials	Tensile Strength(MPa)	Total Elongation(%)
I1	812	19.0
I2	803	21.6
I3	819	20.3
I4	793	20.5
I5	827	19.2
I6	823	19.5
I7	814	21.1
R1	916	16.4
R2	899	12.6
R3	868	14.7
R4	918	16.5

I = according to the invention; R = reference; underlined values: not according to the invention.

CLAIMS

1. A cold rolled and coated steel sheet having a composition comprising of the following elements, expressed in percentage by weight:

0.12 % ≤ Carbon ≤ 0.2 %
1.7% ≤ Manganese ≤ 2.10%
0.1 % ≤ Silicon ≤ 0.5 %
0.1% ≤ Aluminum ≤ 0.8%
0.1% ≤ Chromium ≤ 0.5 %
0 % ≤ Phosphorus ≤ 0.09 %
0 % ≤ Sulfur ≤ 0.09 %.
0 % ≤ Nitrogen ≤ 0.09%

and can contain one or more of the following optional elements

Nickel ≤ 3%
Niobium ≤ 0.1%
Titanium ≤ 0.1%
Calcium ≤ 0.005%
Copper ≤ 2%
Molybdenum ≤ 0. 5%
Vanadium ≤ 0.1%
Boron ≤ 0.003%
Cerium ≤ 0.1%
Magnesium ≦ 0.010%
Zirconium ≦ 0.010%

the remainder composition being composed of iron and unavoidable impurities caused by processing, the microstructure of said steel sheet comprising in area fraction, 10 to 60% Bainite, 25 to 55% Ferrite, 5% to 15% Residual Austenite wherein carbon content in residual austenite is between 0.7% and 1% and 5% to 18% Martensite, wherein the cumulated amount of Bainite and Ferrite is at least 70%.

2. Cold rolled and coated steel sheet according to claim 1, wherein the composition includes 0.1% to 0.4% of Silicon.

3. Cold rolled and coated steel sheet according to claim 1 or 2, wherein the composition includes 0.12% to 0.19% of Carbon.

4. Cold rolled and coated steel sheet according anyone of claims 1 to 3, wherein the composition includes 0.2% to 0.8% of Aluminum.

5. Cold rolled and coated steel sheet according to anyone of claims 1 to 4, wherein the composition includes 1.7% to 2.08% of Manganese.

6. Cold rolled and coated steel sheet according to anyone of claims 1 to 5, wherein the composition includes 0.1% to 0.4% of Chromium.

7. Cold rolled and coated steel sheet according to claim 5, wherein the composition includes 1.8% to 2.08% of Manganese.

8. Cold rolled and coated steel sheet according to claim 3, wherein the composition includes 0.14 % to 0.18% of Carbon.

9. Cold rolled and coated steel sheet according to anyone of claims 1 to 8, wherein, the cumulated amounts of Carbon and Manganese is between 2.1% and 2.25%.

10. Cold rolled and coated steel sheet according to anyone of claims 1 to 9, wherein, the cumulated amount of Silicon and Aluminum is between 0.5% and 0.9%.

11. Cold rolled and coated steel sheet according to anyone of claims 1 to 10, wherein, the cumulated amounts of Ferrite and Bainite is more than or equal to 74% and the percentage of Ferrite is at least 30%.

12. Cold rolled and coated steel sheet according to anyone of claims 1 to 11, wherein the carbon content of residual austenite is between 0.7% and 0.9%.

13. Cold rolled and coated steel sheet according to claim 12, wherein the carbon content of residual austenite is between 0.7% and 0.8%

14. Cold rolled and coated steel sheet according to anyone of claims 1 to 13, wherein the bainite is between 20% and 60%.

15. Cold rolled and coated steel sheet according to anyone of claims 1 to 14, wherein the martensite is between 5% and 15%.

16. Cold rolled and coated steel sheet according to anyone of claims 1 to 15, wherein said steel sheet has an ultimate tensile strength of 780 MPa or more, and a total elongation of 18% or more.

17. Cold rolled and coated steel sheet according to claim 16, wherein said steel sheet has an ultimate tensile strength of 800 MPa or more and a total elongation of greater than equal to 20%.

18. A method of production of a cold rolled and coated steel sheet comprising the following successive steps:
    - providing a steel composition according to anyone of claims 1 to 10;
    - reheating said semi-finished product to a temperature between 1000°C and 1280°C;
    - rolling the said semi-finished product in the temperature range between Ac3 and Ac3 +100°C wherein the hot rolling finishing temperature shall be above Ac3 to obtain a hot rolled steel;
    - cooling the hot rolled steel at a cooling rate above 30°C/s to a coiling temperature which is between 475°C and 650°C; and coiling the said hot rolled steel;
    - cooling the said hot rolled steel to room temperature;
    - optionally performing scale removal process on said hot rolled steel sheet;
    - optionally annealing is performed on hot rolled steel sheet between 400°C and 750°C;
    - optionally performing scale removal process on said hot rolled steel sheet;

- cold rolling the said hot rolled steel sheet with a reduction rate between 35 and 90% to obtain a cold rolled steel sheet;
- annealing the said cold rolled steel sheet in two steps heating wherein:
    - the first step starts from heating the steel sheet from room temperature to a temperature T1 between 600°C and 750°C, with a heating rate HR1 of at least 3°C/s,
    - the second step starts from heating further the steel sheet from T1 to a soaking temperature T2 between Ac1 and Ac3, with a heating rate HR2 of 15°C/s or less, HR2 being lower than HR1,
- then perform annealing at T2 during 10 to 500 seconds,
- then cooling the cold rolled steel sheet from T2 to an overaging temperature T_{over} between 375°C and 480°C at an average cooling rate of at least 10°C/s, wherein such cooling can include an optional slow cooling sub-step between T2 and a temperature Tsc between 600°C and 750°C with a slow cooling rate of 2°C/s or less,
- then the said cold rolled steel sheet is overaged at T_{over} during 5 to 500 seconds and brought to a temperature range between 420°C and 680°C to facilitate coating,
- then coating the cold rolled sheet to obtain a cold rolled coated steel sheet.

19. A method according to claim 18, wherein the coiling temperature is between 475°C and 625°C.

20. A method according to claim 18 or 19, wherein the finishing rolling temperature is more than 850°C.

21. A method according to anyone of claims 18 to 20, wherein the average cooling rate after annealing is more than 15°C/s.

22. A method according to anyone of claims 18 to 21, wherein T2 is between Ac1+30°C and Ac3 and T2 is selected so as to ensure the presence of at least 60% of austenite at the end of the annealing.

23. A method according to claim 22, wherein T2 is between Ac1+30°C and Ac3 and T2 is selected so as to ensure the presence of at least 70% of austenite at the end of the annealing.

24. A method according to anyone of claims 18 to 23, wherein the temperature for overaging Tover is between 380°C and 460°C.

25. A method according to anyone of claims 18 to 24, wherein the first step of heating the cold rolled steel sheet ends at a temperature T1 between 650°C and 750°C with a heating rate HR1 of at least 5°C/s.

26. Use of a steel sheet according to anyone of claims 1 to 17 or of a steel sheet produced according to the method of claims 18 to 25, for the manufacture of structural or safety parts of a vehicle.

27. Vehicle comprising a part obtained according to claim 26.