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(54) Titre : TOLE D'ACIER LAMINEE A FROID ET TRAITEE THERMIQUEMENT, SON PROCEDE DE PRODUCTION ET UTILISATION D'UN TEL ACIER POUR PRODUIRE DES PIECES DE VEHICULE
(54) Title: COLD ROLLED AND HEAT TREATED STEEL SHEET, METHOD OF PRODUCTION THEREOF AND USE OF SUCH STEEL TO PRODUCE VEHICLE PARTS

(57) Abrégé/Abstract:
The invention deals a cold rolled and heat treated steel sheet having a composition comprising the following elements, expressed in % by weight: 0.1 % ≤ carbon ≤ 0.6 % 4 % ≤ manganese ≤ 20 % 5 % ≤ aluminum ≤ 15 % 0 ≤ silicon ≤ 2 % aluminium + silicon + nickel ≥ 6.5% and can possibly contain one or more of the following optional elements: 0.01% ≤ niobium ≤ 0.3%, 0.01% ≤ titanium ≤ 0.2% 0.01% ≤ vanadium ≤ 0.6% 0.01% ≤ copper ≤ 2.0% 0.01% ≤ nickel ≤ 2.0% cerium ≤ 0.1% boron ≤ 0.01% magnesium ≤ 0.05% zirconium ≤ 0.05% molybdenum ≤ 2.0% tantalum ≤ 2.0% tungsten ≤ 2.0% the remainder being composed of iron and unavoidable impurities caused by elaboration, wherein the microstructure of said steel sheet comprises in area fraction, 10 to 50 % of austenite, said austenite phase optionally including intragranular kappa carbides, the reminder being regular ferrite and ordered ferrite of D03 structure $(Fe,Mn,X)_3Al$, optionally including up to 2% of intragranular kappa carbides $(Fe,Mn)_3AlC_x$ said steel sheet presenting a ultimate tensile strength higher than or equal to 900 MPa. It also deals with a manufacturing method and with use of such grade for making vehicle parts.

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(54) **Title:** COLD ROLLED AND HEAT TREATED STEEL SHEET, METHOD OF PRODUCTION THEREOF AND USE OF SUCH STEEL TO PRODUCE VEHICLE PARTS

(57) **Abstract:** The invention deals a cold rolled and heat treated steel sheet having a composition comprising the following elements, expressed in % by weight: 0.1 % ≤ carbon ≤ 0.6 % 4 % ≤ manganese ≤ 20 % 5 % ≤ aluminum ≤ 15 % 0 ≤ silicon ≤ 2 % aluminium + silicon + nickel ≥ 6.5% and can possibly contain one or more of the following optional elements: 0.01% ≤ niobium ≤ 0.3%, 0.01% ≤ titanium ≤ 0.2% 0.01% ≤ vanadium ≤ 0.6% 0.01% ≤ copper ≤ 2.0% 0.01% ≤ nickel ≤ 2.0% cerium ≤ 0.1% boron ≤ 0.01% magnesium ≤ 0.05% zirconium ≤ 0.05% molybdenum ≤ 2.0% tantalum ≤ 2.0% tungsten ≤ 2.0% the remainder being composed of iron and unavoidable impurities caused by elaboration, wherein the microstructure of said steel sheet comprises in area fraction, 10 to 50 % of austenite, said austenite phase optionally including intragranular kappa carbides, the reminder being regular ferrite and ordered ferrite of D03 structure $(Fe,Mn,X)_3Al$, optionally including up to 2% of intragranular kappa carbides $(Fe,Mn)_3AlC_X$ said steel sheet presenting a ultimate tensile strength higher than or equal to 900 MPa. It also deals with a manufacturing method and with use of such grade for making vehicle parts.

WO 2019/123239 A1

Cold rolled and heat treated steel sheet, method of production thereof and use of such steel to produce vehicle parts

This invention relates to a low density steel having a tensile strength greater than or equal to 900MPa with uniform elongation of greater than or equal to 9%, suitable for automotive industry and a method for manufacturing thereof.

Environmental restrictions are forcing automakers to continuously reduce the CO_2 emissions of their vehicles. To do that, automakers have several options, whereby their principal options are to reduce the weight of the vehicles or to improve the efficiency of their engine systems. Advances are frequently achieved by a combination of the two approaches. This invention relates to the first option, namely the reduction of the weight of the motor vehicles. In this very specific field, there is a two-track alternative:

The first track consists of reducing the thicknesses of the steels while increasing their levels of mechanical strength. Unfortunately, this solution has its limits on account of a prohibitive decrease in the rigidity of certain automotive parts and the appearance of acoustical problems that create uncomfortable conditions for the passenger, not to mention the unavoidable loss of ductility associated with the increase in mechanical strength.

The second track consists of reducing the density of the steels by alloying them with other, lighter metals. Among these alloys, the low-density ones called iron-aluminum alloys have attractive mechanical and physical properties while making it possible to significantly reduce the weight. In this case, low density means a density less than or equal to 7.4.

JP 2005/015909 describes a low density TWIP steels with very high manganese contents of over 20% and also containing aluminum up to 15%, resulting in a lighter steel matrix, but the steel disclosed presents a high deformation resistance during rolling together with weldability issues.

The purpose of the present invention is to make available cold-rolled steel sheets that simultaneously have:

- a density less than or equal to 7.4
- an ultimate tensile strength greater than or equal to 900 MPa and preferably equal or above 1000 MPa,
- an uniform elongation greater than or equal to 9%.

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

This object is achieved by providing a steel sheet according to claim 1. The steel sheet can also comprise characteristics of claims 2 to 3. Another object is achieved by providing the method according to claim 4. Another aspect is achieved by providing parts or vehicles according to claims 5 to 7.

In order to obtain the desired steel of present invention, the composition is of significant importance; therefore the detailed explanation of the composition is provided in the following description.

Carbon content is between 0.10% and 0.6% and acts as a significant solid solution strengthening element. It also enhances the formation of kappa carbides $(Fe,Mn)_3AlC_x$. Carbon is an austenite-stabilizing element and triggers a strong reduction of the martensitic transformation temperature Ms, so that a significant amount of residual austenite is secured, thereby increasing plasticity. Maintaining carbon content in the above range, ensure to provide the steel sheet with the required levels of the strength and ductility. It also allows reducing the manganese content while still obtaining some TRIP effect.

Manganese content must be between 4% and 20%. This element is gammagenous. The ratio of the manganese content to the aluminum content will have a strong influence on the structures obtained after hot rolling. The purpose of adding manganese is essentially to obtain a structure that contains austenite in addition to ferrite and to stabilize it at room temperature. With a manganese content under 4, the austenite will be insufficiently stabilized with the risk of premature transformation into martensite during cooling at the exit from the annealing line. Moreover, addition of manganese increases the $D0_3$ domain, allowing getting enough precipitation of $D0_3$ at higher temperatures and/or at lower amounts of aluminium. Above 20%, there is a reduction in the fraction of ferrite which adversely affects the present invention, as it may make it more difficult to reach the required tensile strength. In a preferred embodiment, the addition of manganese will be limited to 17%.

The aluminium content is between 5% and 15%, preferably between 5.5% and 15%. Aluminium is an alphagenous element and therefore tends to promote the formation of ferrite and in particular of ordered ferrite $(Fe,Mn,X)_3Al$ of $D0_3$ structure (X is any solute additions, e.g. Ni, that dissolves in $D0_3$).The aluminum has a density of 2.7 and has an important influence on the mechanical properties. As the aluminum content increases, the mechanical strength and the elastic limit also increase although the uniform elongation decreases, due to the decrease in the mobility of dislocations. Below 4%, the density reduction due to the presence of aluminum becomes less beneficial. Above 15%, the presence of ordered ferrite increases beyond the expected limit and affects the present invention negatively, as it starts imparting brittleness to the steel sheet. Preferably, the aluminum content will be limited to less than 9% to prevent the formation of additional brittle intermetallic precipitation.

In addition to the above limitations, in a preferred embodiment, manganese, aluminium and carbon contents respect the following relationship:

$$0.3 < (Mn/2Al) \times \exp(C) < 2.$$

Below 0.3, there is a risk that austenite amount is too low, possibly leading to insufficient ductility. Above 2, it may be possible that the austenite volume fraction goes higher than 49%, thereby reducing the potential of the precipitation of $D0_3$ phase.

Silicon is an element that allows reducing the density of the steel and is also effective in solid solution hardening. It further has a positive effect of stabilizing $D0_3$ versus B2 phase. Its content is limited to 2.0% because above that level this element has a tendency to form strongly adhesive oxides that generate surface defects. The presence of surface oxides impairs the wettability of the steel and may produce defects during a potential hot-dip galvanizing operation. In a preferred embodiment, the silicon content will preferably be limited to 1.5%.

The inventors have found out that the cumulated amounts of silicon, aluminium and nickel had to be at least equal to 6.5% to obtain the required precipitation of $D0_3$ that allows reaching the targeted properties.

Niobium may be added as an optional element in an amount of 0.01 to 0.3% to the steel of present invention to provide grain refinement. The grain refinement allows obtaining a good balance between strength and elongation and is believed to contribute to improved fatigue performance. But, niobium had a tendency to retard the recrystallization during hot rolling and is therefore not always a desirable element. Therefore it is kept as an optional element.

Titanium may be added as an optional element in an amount of 0.01% to 0.2% to the steel of present invention for grain refinement, in a similar manner as niobium. It further has a positive effect of stabilizing $D0_3$ versus B2 phase. Therefore, the unbounded part of titanium that is not precipitated as nitride, carbide or carbonitride will stabilize the $D0_3$ phase.

Vanadium may be added as an optional element in an amount of 0.01% to 0.6%. When added, vanadium can form fine carbo-nitrides compounds during the annealing, these carbo-nitrides providing additional hardening. It further has a positive effect of stabilizing D03 versus B2 phase. Therefore, the unbounded part of vanadium that is not precipitated as nitride, carbide or carbonitride will stabilize the $D0_3$ phase.

Copper may be added as an optional element in an amount of 0.01% to 2.0% to increase the strength of the steel and to improve its corrosion resistance. A minimum of 0.01% is required to get such effects. However, when its content is above 2.0%, it can degrade the surface aspect.

Nickel may be added as an optional element in an amount of 0.01 to 2.0% to increase the strength of the steel and to improve its toughness. It also contributes to the formation of ordered ferrite. A minimum of 0.01% is required to get such effects. However, when its content is above 2.0%, it tends to stabilize B2 which would be detrimental to $D0_3$ formation.

Other elements such as cerium, boron, magnesium or zirconium can be added individually or in combination in the following proportions: REM ≤0.1%, B ≤ 0.01, Mg ≤ 0.05 and Zr ≤ 0.05. Up to the maximum content levels indicated, these elements make it possible to refine the ferrite grain during solidification.

Finally, molybdenum, tantalum and tungsten may be added to stabilize the $D0_3$ phase further. They can be added individually or in combination up to maximum content levels: Mo ≤ 2.0, Ta ≤ 2.0, W ≤ 2.0. Beyond these levels the ductility is compromised.

The microstructure of the sheet claimed by the invention comprises, in area fraction, 10 to 50% of austenite, said austenite phase optionally including intragranular $(Fe,Mn)_3AlC_x$ kappa carbides, the reminder being ferrite, which includes regular ferrite and ordered ferrite of $D0_3$ structure and optionally up to 2% of intragranular kappa carbides.

Below 10% of austenite, the uniform elongation of at least 9% cannot be obtained.

Regular ferrite is present in the steel of present invention to impart the steel with high formability and elongation and also, to a certain degree, some resistance to fatigue failure.

$D0_3$ ordered ferrite in the frame of the present invention, is defined by intermetallic compounds whose stoichiometry is $(Fe,Mn,X)_3Al$. The ordered ferrite is present in the steel of present invention with a minimum amount of 0.1% in area fraction, preferably of 0.5%, more preferably of 1.0% and advantageously of more than 3%. Preferably, at least 80% of such ordered ferrite has an average size below 30 nm, preferably below 20 nm, more preferably below 15 nm, advantageously below 10 nm or even below 5 nm. This ordered ferrite is formed during the second annealing step providing strength to the alloy by which the levels of 900 MPa can be reached. If ordered ferrite is not present, the strength level of 900MPa cannot be reached.

Kappa carbide, in the frame of the present invention, is defined by precipitates whose stoichiometry is $(Fe,Mn)_3AlC_x$, where x is strictly lower than 1. The area fraction of kappa carbides inside ferrite grains can go up to 2%. Above 2%, the ductility decreases and uniform elongation above 9% is not achieved. In addition, uncontrolled precipitation of Kappa carbide around the ferrite grain boundaries may occur, increasing, as a consequence, the efforts during hot and/or cold rolling. The kappa carbide can also be present inside the austenite phase, preferably as nano-sized particles with a size below 30nm.

The steel sheets according to the invention can be obtained by any suitable process. It is however preferable to use the method according to the invention that will be described.

The process according to the invention includes providing a semi-finished casting of steel with a chemical composition within the range of the invention as described above. The casting can be done either into ingots or continuously in form of slabs or thin strips.

For the purpose of simplification, the process according to the invention will be further described taking the example of slab as a semi-finished product. The slab can be directly rolled after the continuous casting or may be first cooled to room temperature and then reheated.

The temperature of the slab which is subjected to hot rolling must be below 1280°C, because above this temperature, there would be a risk of formation of rough ferrite grains resulting in coarse ferrite grain which decreases the capacity of these grains to re-crystallize during hot rolling. The larger the initial ferrite grain size, the less easily it re-crystallizes, which means that reheat temperatures above 1280°C must be avoided because they are industrially expensive and unfavorable in terms of the recrystallization of the ferrite. Coarse ferrite also has a tendency to amplify the phenomenon called “roping”.

It is desired to perform the rolling with at least one rolling pass in the presence of ferrite. The purpose is to enhance partition of elements that stabilize austenite into austenite, to prevent carbon saturation in the ferrite, which can lead to brittleness. The final rolling pass is performed at a temperature greater than 800°C, because below this temperature the steel sheet exhibits a significant drop in rollability.

In a preferred embodiment, the temperature of the slab is sufficiently high so that hot rolling can be completed in the inter-critical temperature range and final rolling temperature remains above 850°C. A final rolling temperature between 850°C and 980°C is preferred to have a structure that is favorable to recrystallization and rolling. It is preferred to start rolling at a temperature of the slab above 900°C to avoid excessive load that may be imposed on a rolling mill.

The sheet obtained in this manner is then cooled at a cooling rate, preferably less than or equal to 100°C/s down to the coiling temperature. Preferably, the cooling rate will be less than or equal to 60°C/s.

The hot rolled steel sheet is then coiled at a coiling temperature below 600°C, because above that temperature there is a risk that it may not be possible to control the kappa carbide precipitation inside ferrite up to a maximum of 2%. A coiling temperature above 600°C will also result in significant decomposition of the austenite making it difficult to secure the required amount of such phase. Therefore the preferable coiling temperature for the hot rolled steel sheet of the present invention is between 400°C and 550°C.

An optional hot band annealing can be performed at temperatures between 400°C and 1000°C to improve cold rollability. It can be a continuous annealing or a batch annealing. The duration of the soaking will depend on whether it is continuous annealing (between 50s and 1000s) or batch annealing (between 6h and 24h).

The hot rolled sheets are then cold rolled with a thickness reduction between 35 to 90%.

The obtained cold rolled steel sheet is then subjected to a two-step annealing treatment to impart the steel with targeted mechanical properties and microstructure.

In the first annealing step, the cold rolled steel sheet is heated at a heating rate which is preferably greater than 1°C/s to a holding temperature between 750°C and 950°C for a duration less than 600 seconds to ensure a re-crystallization rate greater than 90% of the strongly work hardened initial structure. The sheet is then cooled to the room temperature whereby preference is given to a cooling rate greater than 30°C/s in order to control kappa carbides inside ferrite or at austenite-ferrite interfaces.

The cold rolled steel sheet obtained after first annealing step can, for example, be then again reheated at a heating rate of at least 10°C/h to a holding temperature between 150°C and 600°C for a duration between 10 seconds and 1000 hours, preferably between 1 hour and 1000 hours or even between 3 hours and 1000 hours and then cooled down to room temperature. This is done to effectively control the formation of D03 ordered ferrite and, possibly, of kappa carbides inside austenite. Duration of holding depends upon on the temperature used.

The cold rolled steel sheet can then be coated with a metallic coating such as zinc or zinc alloys by any suitable method, such as electrodeposition or vacuum coating. Jet vapour deposition is a preferred method for coating the steels according to the invention.

It can also be hot dip coated, which implies a reheating up to a temperature of 460 to 500°C for zinc or zinc alloys coatings. Such treatment shall be done so as not to alter any of the mechanical properties or microstructure of the steel sheet.

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.

Samples of the steel sheets according to the invention and to some comparative grades were prepared with the compositions gathered in table 1 and the processing parameters gathered in table 2. The corresponding microstructures of those steel sheets were gathered in table 3.

Table 1 – Compositions

Grade	C	Mn	Al	Si	Ni	Cu	S	P	(Mn/2Al)* exp(C)	Al+Si+Ni
1*	0.19	8.4	6.1	0.91	-	-	0.005	0.017	0.83	7.01
2*	0.19	8.4	6.2	0.94	-	1.10	0.005	0.017	0.82	7.14
3*	0.22	8.2	7.8	0.27	-	-	<0.001	0.030	0.65	8.07
4*	0.29	6.5	5.9	0.90	-	-	0.005	0.020	0.74	6.80
5*	0.30	6.6	5.8	1.2	-	-	0.004	0.015	0.77	7.00
6*	0.41	6.7	5.9	0.96	-	-	0.004	0.018	0.86	6.86
7	0.19	8.3	6.1	-	-	1.0	0.005	0.017	0.82	6.10
8*	0.19	8.4	6.0	-	0.8	1.0	0.005	0.048	0.85	6.80

* according to the invention

Table 2 – Process parameters

Hot and cold rolling parameters

Trial	Grade	Reheating T (°C)	FR T (°C)	Cooling rate (°C/s)	Coiling T (°C)	CR (%)
A	1	1150	920	60	450	75
B*	1	1150	920	60	450	75
C*	1	1150	920	60	450	75
D	2	1150	920	60	450	75
E*	2	1150	920	60	450	75
F*	2	1150	920	60	450	75
G	3	1180	905	50	500	75
H*	3	1180	905	50	500	75
I*	3	1180	905	50	500	75
J	4	1200	950	60	450	75
K*	4	1200	950	60	450	75
L	5	1150	940	100	450	75
M*	5	1150	940	100	450	75
N	5	1150	940	100	450	75
O*	5	1150	940	100	450	75
P*	6	1150	920	60	450	75
Q*	6	1150	920	60	450	75
R*	6	1150	920	60	450	75
S	7	1150	920	60	450	75
T	7	1150	920	60	450	75
U	8	1150	920	60	450	75
V*	8	1150	920	60	450	75

* according to the invention

Annealing parameters

Trial	Grade	First annealing step			Second annealing step	
		T (°C)	t (s)	Cooling rate (°C/s)	T (°C)	t (h)
A	1	850	136	100	-	-
B*	1	850	136	100	400	72
C*	1	850	136	100	400	110
D	2	850	136	100	-	-
E*	2	850	136	100	400	72
F*	2	850	136	100	400	110
G	3	850	136	100	-	-
H*	3	850	136	100	400	48
I*	3	850	136	100	400	72
J	4	900	136	100	-	-
K*	4	900	136	100	400	110
L	5	850	136	65	-	-
M*	5	850	136	65	400	72
N	5	900	136	65	-	-
O*	5	900	136	65	400	72
P*	6	850	136	55	400	48
Q*	6	850	136	55	450	7
R*	6	900	136	55	450	7
S	7	800	136	100	-	-
T	7	800	136	100	400	168
U	8	800	136	100	-	-
V*	8	800	136	100	400	168

* according to the invention

Table 3 - Microstructures

Trial	Grade	Austenite including Kappa (%)	Kappa in austenite	Regular ferrite + $D0_3$ ferrite (%)	Kappa in ferrite (%)	$D0_3$ ferrite
A	1	25	No	75	-	No
B*	1	25	Yes **	75	-	> 0.1%
C*	1	25	Yes	75	-	> 0.1%
D	2	25	No	75	-	No
E*	2	25	Yes **	75	-	> 0.1%
F*	2	25	Yes	75	-	> 0.1%
G	3	18	No	80	2	No
H*	3	18	Yes **	80	2	> 0.1%
I*	3	18	Yes**	80	2	> 0.1%
J	4	31	No	69	-	No
K*	4	32	Yes	68	-	> 0.1%
L	5	34	No	66	-	No
M*	5	34	Yes **	66	-	> 0.1%
N	5	35	No	65	-	No
O*	5	35	Yes **	65	-	> 0.1%
P*	6	41	No	59	-	> 0.1%
Q*	6	40	No	60	<2	> 0.1%
R*	6	43	No	57	<2	> 0.1%
S	7	29	No	71	-	No
T	7	27	Yes	73	-	< 0.1%
U	8	28	No	72	-	No
V*	8	28	Yes	72	-	> 0.1%

** Early stages of Kappa precipitation in austenite detected by transmission electron microscopy. The austenitic microstructure remains stable after the second heat treatment, without decomposition in other phases like pearlite or bainite.

Phase proportions and Kappa precipitation in austenite and ferrite are determined by electron backscattered diffraction and transmission electron microscopy.

$D0_3$ precipitation is determined by diffraction with an electronic microscope and by neutron diffraction as described in “Materials Science and Engineering: A, Volume 258, Issues 1–2, December 1998, Pages 69-74, *Neutron diffraction* *study on site occupation of substitutional elements at sub lattices in Fe3 Al intermetallics* (Sun Zuqing, Yang Wangyue, Shen Lizhen, Huang Yuanding, Zhang Baisheng, Yang Jilian)”.

Some microstructure analyses were performed on samples from trial E and images of $D0_3$ structure are reproduced on Figures 1 (a) and 1 (b):

(a) Dark field image of $D0_3$ structure

(b) Corresponding diffraction pattern, zone axis [100] $D0_3$. Arrow indicates the reflection used for the dark field image in (a)

The properties of those steel sheets were then evaluated, the results being gathered in table 4.

<u>Table 4 – Properties</u>

Trial	Grade	YS (MPa)	UTS (MPa)	UE (%)	TE (%)	Density
A	1	623	<u>788</u>	17.6	28.5	7.16
B*	1	870	1008	9.6	16.6	7.16
C*	1	900	1034	9.3	16.2	7.16
D	2	626	<u>788</u>	16.3	25.8	7.15
E*	2	899	1041	9.3	15.1	7.15
F*	2	916	1068	9.1	13	7.15
G	3	633	<u>774</u>	15.5	24.4	7.02
H*	3	771	902	10	18.9	7.02
I*	3	787	913	9.4	19	7.02
J	4	633	<u>795</u>	18.1	29.4	7.18
K*	4	849	976	10.8	18.2	7.18
L	5	692	<u>851</u>	17.9	28.5	7.18
M*	5	878	1024	11	18.8	7.21
N	5	655	<u>840</u>	19.5	31.3	7.21
O*	5	861	1014	11.8	20.7	7.21
P*	6	962	1032	12.3	21.5	7.18

Q*	6	990	1047	11.1	19.1	7.18
R*	6	865	974	12.8	23.0	7.18
S	7	600	<u>713</u>	16.6	23.6	7.18
T	7	744	<u>826</u>	13.2	20.4	7.18
U	8	659	<u>765</u>	15.6	25	7.19
V*	8	815	912	12.5	20.1	7.19

The yield strength YS, the tensile strength TS, the uniform elongation UE and total elongation TE are measured according to ISO standard ISO 6892-1, published in October 2009. The density is measured by pycnometry, according to ISO standard 17.060.

The examples show that the steel sheets according to the invention are the only one to show all the targeted properties thanks to their specific composition and microstructures.

CLAIMS

1. A cold rolled and heat treated steel sheet having a composition comprising the following elements, expressed in per cent by weight:

   0.10 % ≤ carbon ≤ 0.6 %
   4 % ≤ manganese ≤ 20 %
   5 % ≤ aluminum ≤ 15 %
   0 ≤ silicon ≤ 2 %
   aluminium + silicon + nickel ≥ 6.5%

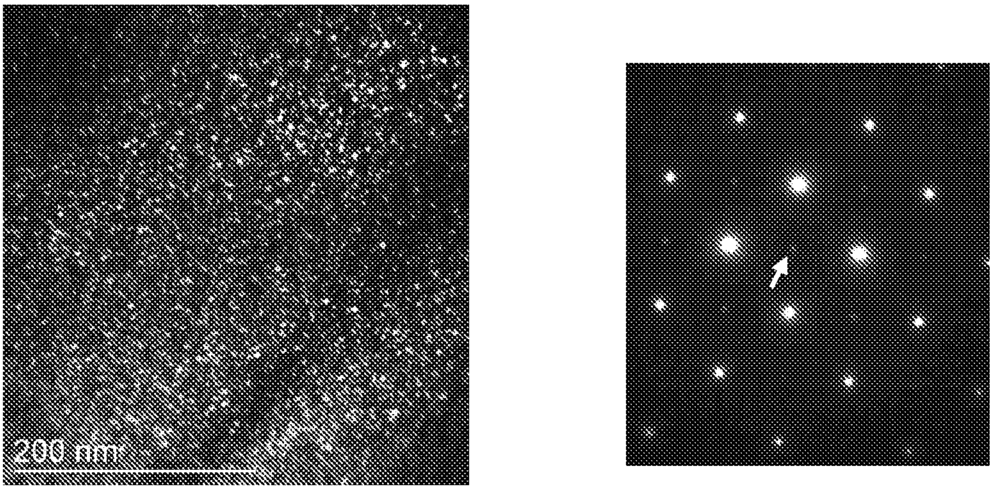
   and can possibly contain one or more of the following optional elements:

   0.01% ≤ niobium ≤ 0.3%,
   0.01% ≤ titanium ≤ 0.2%
   0.01% ≤ vanadium ≤ 0.6%
   0.01% ≤ copper ≤ 2.0%
   0.01% ≤ nickel ≤ 2.0%
   cerium ≤ 0.1%
   boron ≤ 0.01%
   magnesium ≤ 0.05%
   zirconium ≤ 0.05%
   molybdenum ≤ 2.0%
   tantalum ≤ 2.0%
   tungsten ≤ 2.0%

   the remainder being composed of iron and unavoidable impurities caused by elaboration, wherein the microstructure of said steel sheet comprises in area fraction, 10 to 50 % of austenite, said austenite phase optionally including intragranular kappa carbides, the reminder being regular ferrite and ordered ferrite of D03 structure $(Fe,Mn,X)_3Al$, optionally including up to 2% of intragranular kappa carbides $(Fe,Mn)_3AlC_x$, said steel sheet presenting a ultimate tensile strength higher than or equal to 900 MPa.

2. A cold rolled and heat treated steel sheet according to claim 1 wherein aluminium, manganese and carbon amounts are such that $0.3 < (Mn/2Al) \times \exp(C) < 2$.
3. A cold rolled and heat treated steel sheet according to claims 1 to 2, wherein said steel sheet present a density of less than or equal to 7.4 and a uniform elongation higher than or equal to 9%.
4. A method of production of a cold rolled and heat treated steel sheet comprising the following steps:
    - providing a cold rolled steel sheet with a composition according to claims 1 to 2,
    - heating said cold rolled steel sheet up to a soaking temperature between 750 and 950°C during less than 600 seconds, then cooling the sheet down to room temperature,
    - reheating the steel sheet to a soaking temperature of 150°C to 600°C during 10 s to 1000 h, then cooling the sheet.
5. Use of a steel sheet produced according to anyone of claims 1 to 3 or of a steel sheet produced according to the method of claim 4, for the manufacture of structural or safety parts of a vehicle.
6. Part according to claim 5, by flexible rolling of said steel sheet.
7. Vehicle comprising a part obtained according to anyone of claims 5 or 6.

FIG 1



(a) (b)