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(54) Title: COLD ROLLED, COATED AND POST TEMPERED STEEL SHEET AND METHOD OF MANUFACTURING THEREOF

(57) Abstract: The invention deals with a method of manufacturing of cold rolled, coated and post tempered steel sheet which microstructure comprises, in surface percentage, 15- 75 % of hardened ferrite, tempered martensite and can also comprise retained austenite, so that cumulated percentages of tempered martensite and retained austenite are from 15-70%, wherein a cold rolled and coated steel sheet which microstructure comprises, in surface percentage, 15-75% of solid solution-hardened ferrite, martensite and can also comprise retained austenite, so that cumulated percentages of martensite and retained austenite are from 15-70%, is submitted to a post tempering heat treatment at a temperature of 150-500 °C during a time of 10 seconds to 48 hours, such time and temperature being chosen so as to limit iron diffusion from the sheet to the coating to 0 to 5% in addition to the initial iron content of said coating, while so reducing the hardness difference between the hardened ferrite and martensite. The invention also deals with a cold rolled, coated and post tempered steel sheet obtained with this method.



COLD ROLLED, COATED AND POST TEMPERED STEEL SHEET AND METHOD OF MANUFACTURING THEREOF

As the use of high strength steels increases in automotive applications, there is a growing demand for steels of increased strength without sacrificing formability. Growing demands for weight saving and safety requirement motivate intensive elaborations of new concepts of automotive steels that can achieve higher ductility simultaneously with higher strength in comparison with the existing Advanced High Strength Steels (AHSS).

Thus, several families of steels like the ones mentioned below offering various strength levels have been proposed.

Firstly, steels have been proposed that have micro-alloying elements whose hardening is obtained simultaneously by precipitation and by refinement of the grain size. The development of such steels has been followed by those of higher strength called Advanced High Strength Steels which keep good levels of strength together with good cold formability.

For the purpose of obtaining even higher tensile strength levels with better ductility, steels exhibiting TRIP (Transformation Induced Plasticity) behaviour with highly advantageous combinations of properties (tensile strength/deformability) have been developed. These properties are associated with the structure of such steels, which consists of a ferritic matrix containing bainite, martensite and residual austenite. The residual austenite is stabilized by an addition of silicon or aluminium, these elements retarding the precipitation of carbides in the austenite and in the bainite. The presence of residual austenite gives an undeformed sheet high ductility. Under the effect of a subsequent deformation, for example when stressed uni-axially, the residual austenite of a part made of TRIP steel is progressively transformed to martensite, resulting in substantial hardening and delaying the appearance of necking.

To achieve an even higher tensile strength, that is to say a level greater than 800-1000 MPa, multiphase steels having a predominantly bainitic structure have been developed. In the automotive industry or in industry in general, such steels are advantageously used for structural parts such as bumper cross-members, pillars, various reinforcements and abrasion-resistant wear parts. However, the formability of these parts requires, simultaneously, a sufficient elongation, greater than 10% and

not a too high yield strength/tensile strength ratio so as to have a sufficient reserve of plasticity.

All these steel sheets present relatively good balances of resistance and ductility, but an improvement in yield strength and hole expansion performance over steels currently in production is needed, in particular for coated steel sheets.

The invention is defined in claims 1 to 7 directed to a method of manufacturing cold rolled, coated and post tempered steel sheet, in claims 8 to 15 directed to a cold rolled, coated and post tempered steel sheet and in claims 16 and 17 respectively directed to a structural part and to a vehicle including such part.

As will be made clear in the present specification, the invention is based on the finding that a post tempering treatment performed on an already coated steel sheet can drastically improve the formability of said sheet without damaging said coating. In particular, said post tempering treatment does reduce the difference of hardness between the ferrite and martensite, which are the main phases of the microstructure of the steel. Such reduction of hardness difference was recognized as being at the origin of a significant improvement of the hole expansion properties.

Other features and advantages of the invention will appear through the following detailed description.

As already mentioned the microstructure of the final coated and tempered steel sheet contains mandatory phases that are, as surface fraction, 15% to 75 % of hardened ferrite and tempered martensite. The microstructure can also comprise retained austenite. Such retained austenite can include pure retained austenite and martensite-austenite islands (so called MA islands). The cumulated amounts of tempered martensite and austenite (whatever the form) are in the range 15-70%.

A steel microstructure according to the invention can therefore contain:

- hardened ferrite, tempered martensite (so-called tempered high yield Dual phase)
- hardened ferrite, tempered martensite and retained austenite (so called tempered TRIP)

- hardened ferrite, tempered martensite and MA islands (so called tempered TRIP aided DP).

Ferrite in the frame of the present invention is defined by a cubic centre
5 structure. Such ferrite definition includes also bainitic ferrite which can very hardly be distinguished from other kinds of ferrite.

Ferrite can be hardened by introduction of one or more elements in solid
solution. Silicon and/or manganese are usually added to such steels for that purpose.
Such hardening usually occurs during annealing of cold rolled steel sheet and is
10 therefore effective before the post tempering operation but does not impair processability.

Moreover, ferrite can be hardened by precipitation of elements forming, for
example, carbides, nitrides or carbonitrides. Elements of micro-alloying such as
titanium, niobium or vanadium can be mentioned and will be further detailed. Such
15 precipitation will preferably mostly occur during the post tempering process step, so has not to harden the steel too much before it is rolled.

In the present invention, both ways of hardening ferrite can be used,
alternatively or at the same time, depending on the composition of the steel.

Its content must be between 15 and 75% so as to have at least 780MPa of
20 tensile strength, with at least 500 MPa of yield strength and at least 12% of total elongation.

Martensite is the structure formed during cooling after the soaking from the
unstable austenite formed during annealing. It is further tempered during the post
tempering process step. One of the effects of such tempering is the lowering of the
25 carbon content of the martensite, which is therefore less hard and less brittle.

Its content (including the martensite possibly involved in martensite-austenite
islands) can preferably be within the range of 15 to 70% so that the uniform
elongation remains above 5%, preferably above 8%.

Retained austenite can also be present alone or as islands of martensite and
30 austenite.

In any cases, austenite is a structure that brings ductility. Its content is preferably high enough so that the steel of the invention is enough ductile with total elongation preferably above 8% and more preferably above 12%, or above 14% and even better above 18% and its content should not be excessive because it would generate a decrease of the value of the mechanical properties. A preferred range of surface fraction of austenite (pure or inside MA islands) is 3 to 20%, and even better, 5 to 15%.

A steel microstructure according to the invention can therefore contain:

- hardened ferrite, tempered martensite (so-called tempered high yield Dual phase)
- hardened ferrite, tempered martensite and retained austenite (so called tempered TRIP)
- hardened ferrite, tempered martensite and MA islands (so called tempered TRIP aided DP),

As will be further evidenced in the examples detailed below, one of the effects of the post tempering treatment on the mechanical properties of the steel sheet is to lower the tensile strength. Such lowering is mainly due to the tempering of the martensite phase which reduces the carbon content of such phase and hence its hardness.

As a consequence, before proceeding to such post tempering treatment, it is preferred to increase the tensile strength TS_i of the coated steel sheet above the final targeted value TS_f , by any suitable metallurgical way known to the man skilled in the art, so that, after post tempering, the final value is on line with such final targeted value TS_f . A preliminary determination of the decrease ΔTS due to post tempering can be done to set TS_i so that : $TS_i = \Delta TS + TS_f$.

As evidenced hereunder, the post tempering process step will simultaneously increase the ferrite hardness and decrease the martensite hardness, such decreasing the hardness difference between both phases. Such consequence is at the origin of the improvement of the hole expansion properties as will be shown in more details in the following trial section.

In terms of properties, the tempered steel sheet according to the invention preferably presents a hole expansion of more than 20%, or even of more than 25%. Its yield strength is preferably in the range of 550 to 1100 MPa. Its tensile strength is in the range above 780 MPa and preferably under 1380 MPa. Its total elongation is
5 above 12% and preferably in the range of 12 to 25%.

The post tempering treatment according to the invention can be performed by any suitable means, as long as its temperature and time stay within the claimed ranges.

10 In particular, induction annealing can be performed on the uncoiled steel sheet, in a continuous way. Such induction heating is usually performed during ten seconds to ten minutes, depending on the annealing line speed and allows reaching the annealing temperature very quickly. Under ten seconds, no real effect can be seen on the mechanical properties of the steel sheet. On the contrary, after ten minutes of
15 treatment, depending on the temperature of annealing, some degradation of the coating may appear. A preferred range of time can be two to ten minutes.

Another preferred way to perform such post tempering treatment is to perform a so called batch annealing on a coil of the steel sheet. This is done in a batch annealing furnace and lasts usually between 1 and 48 hours, depending on the
20 annealing temperature selected.

Depending on the target values of mechanical properties, the man skilled in the art knows how to define the steel composition and the post tempering parameters (time and temperature) to reach such properties.

The cold rolled coated steel sheet that will be further submitted to the post
25 tempering treatment can be produced by any conventional route, depending on the nature of the steel. The coating can be done by any suitable method including, hot dip coating in zinc- or aluminium-based baths, electrogalvanizing, vacuum coatings (jet vapour deposition), chemical vapour coatings, for instance.

Such coating can be further modified by a subsequent treatment. More
30 particularly, galvanized steel sheets can be submitted to a galvannealing treatment to increase their iron content up to 15% in weight.

In a preferred embodiment, the galvannealing operation is performed until an iron content of less than 12%, preferably less than 7% is obtained and interrupted prematurely depending of post tempering process (temperature and time). This low level of iron can be compensated during post tempering where iron diffusion can be controlled so as to reach the desired amount of iron in the final product. By proceeding in two steps, a better overall control of such content can be attained.

The post tempering heat treatment is however performed such that any additional iron diffusion from the steel to the coating keeps limited to 5% at most.

Steel compositions suitable for use in the present invention can contain a lot of different elements, besides carbon. The most commonly used elements will be detailed.

Carbon is a gamma-former element. It promotes the stabilization of austenite. Moreover, it can be involved in the formation of precipitates that harden ferrite. Below 0.05%, the reachable tensile strength will be quite low. On the other hand, If the carbon content is greater than 0.5%, the cold-rollability is reduced and the weldability becomes poor. Preferably, carbon content is at least of 0.15% to achieve TRIP effect by retained austenite and at most 0.25% C to achieve better weldability.

Manganese is also austenite-stabilizer, and can be used to stabilize enough austenite in the microstructure. It also has a solid solution hardening effect and a refining effect on the microstructure. Its content is however usually limited to less than 10% to avoid weldability, segregations and inclusions issues. In a preferred embodiment, its minimum value is 2% to reach a tensile strength of at least 980 MPa. In another preferred embodiment, its maximum value is 2.5% not to impair Weldability.

Silicon is also very efficient to increase the strength through solid solution. However its content is preferably limited to 2.5%, because beyond this value, the rolling loads increase too much and hot rolling process becomes difficult. Moreover, coatability by hot dip coating may get impaired due to silicon oxide formation on surface of the sheet. The cold-rollability is also reduced. A minimum amount of 0.1%,

or better of 0.5% or even better of 1% is also preferred to secure TRIP effect when needed.

Aluminum additions are interesting for many aspects to increase the stability of retained austenite through an increase of carbon in the retained austenite. Al enables to decrease the hardness of the hot band, which can be then easily cold rolled down to its final thickness. Addition of Al leads to lower variation of austenite fraction as a function of temperature. Aluminium is usually lower or equal to 3.5% to avoid the formation of coarse primary ferrite grains formed during the solidification and not transformed into austenite during further cooling, but above 0.05wt% for its action on retained austenite. In a preferred embodiment, its minimum amount is 0.5% to achieve TRIP effect. In another preferred embodiment, its maximum value is 1% because of the limitation of soak temperature at hot dip Zn coating line.

Molybdenum and chromium increase the hardenability of the steel and promotes the formation of martensite. Their amount are however preferably limited to respectively 0.4% and 0.6% for costs reasons.

Micro-alloying elements such as titanium, vanadium and niobium may be added respectively in a preferred amount less than 0.2% for each, in order to obtain an additional precipitation hardening of ferrite. In particular titanium and niobium are used to control the grain size during the solidification. One limitation, however, is necessary because beyond, a saturation effect is obtained.

Boron can also be added up to a preferred content of 0.0035% to improve hardenability of the steel sheet. Above such limit, a saturation level is expected as regard to such hardenability effect.

As for sulphur, it is usually limited so as to avoid ductility is reduction due to the presence of excess sulphides such as MnS. In particular hole-expansion tests show lower values in presence of such sulphides. It is therefore preferred that sulphur content be limited to 0.005%.

Phosphorus is an element which hardens in solid solution but which reduces the spot weldability and the hot ductility, particularly due to its tendency to segregation at the grain boundaries or co-segregation with manganese. For these

reasons, its content is preferably limited to 0.025 %, and more preferably to 0.020 %, in order to obtain good spot weldability.

The invention will be better understood with the following non limitative examples.

Examples

Abbreviations

- UTS (MPa) refers to the ultimate tensile strength measured by tensile test in the longitudinal direction relative to the rolling direction,
- YS (MPa) refers to the yield strength measured by tensile test in the longitudinal direction relative to the rolling direction,
- TEI (%) refers to the total elongation.

UTS, YS and Tel can be measured following several tests. Tests used for examples 1 and 2 are according to JIS-T standard whereas tests used for example 3 are according to ISO standards.

- HE (%) refers to the hole expansion. Such test can be performed with the help of a conical punch made of a cylindrical part which diameter is 45 mm, topped by a conical part. Such punch is being positioned under the steel sheet to test and which has been previously provided with a hole of an initial diameter D_0 of 10 mm. The conical punch is then being moved upwards into such hole and does enlarge it until a first traversing crack appears. The final diameter D of the hole is then being measured and the hole expansion is calculated using the following relationship :

$$HE = \left(\frac{D - D_0}{D_0} \right) \times 100$$

Another possibility to perform such test is to use a so called flat punch, made of a cylinder with a diameter of 75 mm, all other conditions being similar.

- Microstructures were observed using a SEM at the quarter thickness location, using 2% Nital etching and quantified by image analysis.

Example 1

5 Semi-finished products have been produced from steel castings. The chemical compositions of the semi-finished products, expressed in weight percent, are shown in Table 1 below. The rest of the steel compositions in Table 1 consists in iron and inevitable impurities resulting from the smelting.

	C	Si	Mn	P	S	Cu	Al	Ti	Nb	N	Cr	Ni	B	Mo
1	0.17	1.55	1.81	0.017	0.005	-	0.65	-	0.020	0.0045	-	-	-	0.15
2	0.15	0.7	2.6	0.015	0.003	-	0.8	-	0.010	0.0046	-	-	-	0.15
3	0.21	1.3	1.5	0.016	0.003	-	0.58	-	0.021	0.0042	-	-	10	0.30
4	0.21	1.3	1.5	0.016	0.003	-	0.58	-	0.020	0.0041	-	-	-	0.30

Table 1: Chemical composition (wt%, B in ppm).

10 Ingots of composition 1 to 4 were initially hot rolled to 20 mm thick plates. Then, the plates were reheated and hot-rolled again down to 3.8 mm. The hot rolled steel plates were then cold rolled and annealed. The process parameters undergone are shown hereunder:

- Finishing rolling temperature : 875°C
- 15 – Coiling temperature : 580°C
- Cold rolling reduction rate : around 50%
- Soaking temperature during annealing : 825°C
- Soaking duration during annealing : 150 s.

20 After annealing, coating by hot dip galvanizing in a bath of molten zinc was simulated by heating the steel sheets at a temperature of 460°C, followed by a galvannealing treatment at 575°C.

The microstructure of steel sheets 1 to 4 contains ferrite (including bainitic ferrite), martensite and MA islands in surface proportion given in the Table 2 below, before being submitted to post tempering by two different ways. Such surface

fractions are unchanged after post tempering which is only modifying the carbon concentration inside those phases.

	Ferrite	Martensite + MA islands
1	67	43
2	42	58
3	56	44
4	58	42

Table 2: Microstructures (surface %)

5 Post tempering by batch annealing

Post tempering of a set of steel sheets 1 was performed by heating such steels as a coil in a batch annealing furnace. The heating and cooling rates before and after tempering were done at a rate of 25°C/h. isothermal tempering was done at the desired temperature for 5 hours.

10

	Thickness (mm)	UTS (MPa)	YS (MPa)	Tel (%)	HE (%)
1 (without tempering)	1.41	1227	555	15.6	nm
1 – 200°C	1.36	1195	802	13.9	17

Table 3: Mechanical properties - nm : not measured

It can be seen from Table 3 that the post tempering treatment decreases slightly the tensile strength and the total elongation but increases notably the yield strength and hole expansion properties. In fact the hole expansion of sample 1 without tempering was not measurable as the steel was too brittle.

15

Post tempering by induction heating

Post tempering of a set of steel sheets 2 to 4 was performed by induction heating the steel sheets to reach the desired temperature, which was maintained during the times specified in table 4.

20

	Thickness (mm)	UTS (MPa)	YS (MPa)	Tel (%)	HE (%)
2 (without tempering)	1.59	1319	645	14.2	nm
2 - 300°C - 30 sec	1.56	1240	943	13.6	22.7
2 - 400°C - 30 sec	1.53	1141	969	10.9	33.7
3 (without tempering)	1.52	1308	605	14.3	nm
3 - 300°C - 30 sec	1.54	1221	784	15.3	16.8
3 - 400°C - 30 sec	1.54	1149	896	13.4	32.0
4 (without tempering)	1.42	1235	564	14.8	nm
4 - 250°C - 30 sec	1.37	1158	576	14.8	12.2
4 - 300°C - 30 sec	1.42	1159	729	15.2	17.5

Table 4: Mechanical properties – HE : conical punch

It can be seen from Table 4 that the post tempering treatment decreases slightly the tensile strength but increases notably the yield strength and hole expansion properties. The hole expansion of samples 2, 3 and 4 without tempering was not measurable as the steel was too brittle

Example 2

Semi-finished products have been produced from steel castings. The chemical composition of the semi-finished products, expressed in weight percent, is shown in Table 5 below. The rest of the steel composition in Table 5 consists in iron and inevitable impurities resulting from the smelting.

	C	Si	Mn	P	S	Cu	Al	Ti	Nb	V	N	Cr	Ni	B	Mo
5	0.18	1.52	1.99	0.013	0.005	0.04	0.62	0.005	0.007	0.007	0.0065	0.04	0.01	3	0.15

Table 5: Chemical composition (wt%, B in ppm).

Ingot of composition 5 was initially hot rolled to 20 mm thick plates. Then, the plates were reheated and hot-rolled again down to 3.8 mm. The hot rolled steel plates were then cold rolled and annealed. The process parameters undergone are shown hereunder:

- Finishing rolling temperature : 930°C

- Coiling temperature : 680°C
- Cold rolling reduction rate : around 50%
- Soaking temperature during annealing : 825°C
- Soaking duration during annealing : 150 s.

5 After annealing, coating by hot dip galvanizing in a bath of molten zinc was performed in a bath at a temperature of 460°C, followed by a galvannealing treatment.

The microstructure of steel sheets 5 contains ferrite (including bainitic ferrite), martensite and MA islands in surface proportion according to the invention, before
10 being submitted to post tempering by batch annealing. Such surface fractions are unchanged after post tempering which is only modifying the carbon concentration inside those phases.

Post tempering by batch annealing

15 Post tempering of a set of steel sheets 5 was performed by heating such steels as a coil in a batch annealing furnace. Isothermal tempering was done at the desired temperature for 5 hours. Temper rolling was then performed with 0.3% elongation.

	Thickness (mm)	UTS (MPa)	YS (MPa)	Tel (%)	HE (%)
5 (without tempering)	1.4	1180	560	10	nm
5 – 290°C	1.4	1150	760	15	18

Table 6: Mechanical properties - nm : not measured - HE : conical punch

20 It can be seen from Table 6 that the post tempering treatment decreases slightly the tensile strength and the total elongation but increases notably the yield strength and hole expansion properties. In fact the hole expansion of sample 5 without tempering was not measurable as the steel was too brittle.

After such post tempering, the galvannealed coatings were not damaged and
25 their iron content was 11% without significant increase due to post tempering.

Example 3

Semi-finished products have been produced from a steel casting. The chemical composition of the semi-finished products, expressed in weight percent, is shown in Table 7 below. The rest of the steel composition in Table 7 consists in iron and inevitable impurities resulting from the smelting.

	C	Si	Mn	P	S	Cu	Al	Ti	Nb	N	Cr	Ni	Mo
6	0,22	0,11	1,73	0,02	0,001	0,04	1,49	0,01	0,01	0,01	0,02	0,02	0,13

Table 7: Chemical composition (wt%).

Ingots of composition 6 were initially hot rolled to 4 mm thick plates. The hot rolled steel plates were then cold rolled and annealed. The process parameters undergone are shown hereunder:

- Finishing rolling temperature : 900°C
 - Coiling temperature : 550°C
 - Cold rolling reduction rate : around 50%
 - Soaking temperature during annealing : 850°C
 - Soaking duration during annealing : 100 s
- After annealing, coating by hot dip galvanizing in a bath of molten zinc was performed with an immersion temperature of 455°C, followed by a galvannealing treatment at 540°C.

The microstructure of steel sheet 6 contains 71% of ferrite (including bainitic ferrite), 20% of martensite and 9% of austenite before being submitted to post tempering by two different ways. Such surface fractions are unchanged after post tempering which is only modifying the carbon concentration inside those phases.

Post tempering by batch annealing

Post tempering of a first set of steel sheets 6 was performed by heating such steels as a coil in a batch annealing furnace. Isothermal tempering was done at the desired temperature for 8 hours.

	Thickness (mm)	UTS (MPa)	YS (MPa)	Tel (%)	HE (%)
6 (without tempering)	2	802	486	23.9	17.9
6 – 150°C	2	810	488	25.7	20.0
6 – 200°C	2	805	500	25.8	21.1
6 – 250°C	2	766	544	23.2	25.3
6 – 400°C	2	750	593	18.7	25.3
6 – 500°C	2	706	541	19.8	22.1

Table 8: Mechanical properties - HE : flat punch

Hole expansion was measured by flat punch which is a tougher test than conical punch and gave lower values than hereunder. However, trends are similar whatever the test used.

- 5 It can be seen from Table 8 that the post tempering treatment decreases slightly the tensile strength but increases notably the yield strength and hole expansion properties up to 500°C.

After such post tempering, the galvanized coatings were not damaged and their iron content was 10% without significant increase due to post tempering.

10

Post tempering by induction heating

Post tempering of a second set of steel sheets 6 was performed by induction heating the steel sheets to reach the desired temperature, which was maintained during the times specified in table 9.

	Thickness (mm)	UTS (MPa)	YS (MPa)	Tel (%)	HE (%)
6 (without tempering)	2	802	486	23.9	22.1
6 – 200°C – 2 min	2	806	487	24.6	24.7
6 – 400°C – 2 min	2	795	493	24.1	24.7
6 – 400°C – 10 min	2	751	558	24.5	30.5
6 – 500°C – 2 min	2	802	508	24.1	26.3
6 – 500°C – 10 min	2	779	515	18.9	30

15 Table 9: Mechanical properties - HE : conical punch

It can be seen from Table 9 that the post tempering treatment decreases slightly the tensile strength but increases notably the yield strength and hole expansion properties.

After such post tempering, the galvanized coatings were not damaged and
5 their iron content was 10% without significant increase due to post tempering.

The steel sheets according to the invention will be beneficially used for the manufacture of structural or safety parts in the automobile industry.

CLAIMS

1. Method of manufacturing of cold rolled, coated and post tempered steel sheet which microstructure comprises, in surface percentage, 15-75 % of hardened ferrite, tempered martensite and can also comprise retained austenite, so that cumulated percentages of tempered martensite and retained austenite are from 15-70%, wherein a cold rolled and coated steel sheet which microstructure comprises, in surface percentage, 15-75% of solid solution-hardened ferrite, martensite and can also comprise retained austenite, so that cumulated percentages of martensite and retained austenite are from 15-70%, is submitted to a post tempering heat treatment at a temperature of 150–500 °C during a time of 10 seconds to 48 hours, such time and temperature being chosen so as to limit iron diffusion from the sheet to the coating to 0 to 5% in addition to the initial iron content of said coating, while so reducing the hardness difference between the hardened ferrite and martensite.
2. Method according to claim 1, wherein said post tempering heat treatment is performed at a temperature of 200-400°C.
3. Method according to claim 1 or 2 , wherein said post tempering heat treatment is performed continuously by induction heating of said uncoiled steel sheet, said tempering time being in the range of 10 seconds to 10 minutes.
4. Method according to claim 1 or 2, wherein said post tempering heat treatment is performed by batch annealing of a coil of said steel sheet, said tempering time being in the range of 1 to 48 hours.
5. Method according to anyone of claims 1 to 4, wherein said cold rolled and coated steel sheet is a galvanized steel sheet which coating contains, in weight percentage, 0.1 to 0.3% Al, less than 5% of iron, the reminder being zinc and unavoidable impurities, said tempering temperature and time being chosen so as to limit iron diffusion to reach a maximum content of less than 5%.
6. Method according to anyone of claims 1 to 4, wherein said cold rolled and coated steel sheet is a galvanized steel sheet which coating contains, in weight percentage, 0.05 to 0.2% Al, 5 to 15% of iron, the reminder being zinc and

unavoidable impurities, said tempering temperature and time being chosen to limit iron diffusion to less than 5% in addition to the initial iron content of said coating.

7. Method according to anyone of claims 1 to 6, wherein the decrease of tensile

strength ΔTS generated by said post tempering treatment is first determined and

the tensile strength of said cold rolled and coated steel sheet is set to a value TS_i

equal to the targeted tensile strength value TS_f of said cold rolled, coated and post

tempered steel sheet, plus ΔTS .

8. Cold rolled, coated and post tempered steel sheet which microstructure

comprises, in surface percentage, 15-75% of hardened ferrite, tempered

martensite and can also comprise retained austenite, so that cumulated

percentages of tempered martensite and retained austenite are from 15-70%, the

coating comprising, in weight percentage less than 15 % of iron, said cold rolled,

coated and post tempered steel sheet presenting a hole expansion of more than

20% when measured with a conical punch.

9. Cold rolled, coated and post tempered steel sheet according to claim 8, which

hole expansion is more than 25% when measured with a conical punch.

10. Cold rolled, coated and post tempered steel sheet according to claim 8 or 9, which

yield strength is in the range 550 to 1100 MPa.

11. Cold rolled, coated and post tempered steel sheet according to anyone of claims 8

to 10, which tensile strength is in the range 780 to 1380 MPa.

12. Cold rolled, coated and post tempered steel sheet according to anyone of claims

8 to 11 which total elongation is in the range 8 to 25%.

13. Cold rolled, coated and post tempered steel sheet according to anyone of claims

8 to 12 which is chosen among TRIP, TRIP aided dual phase and High yield Dual

phase steel.

14. Cold rolled, coated and post tempered steel sheet according to anyone of claims

8 to 13, which coating contains, in weight percentage, 0.1 to 0.3% Al, less than

5% of iron, the reminder being zinc and unavoidable impurities.

15. Cold rolled, coated and post tempered steel sheet according to anyone of claims

8 to 13, which coating contains, in weight percentage, 0.05 to 0.2% Al, 5 to 15% of

iron, the reminder being zinc and unavoidable impurities.

16. Structural part including a cold rolled, coated and post tempered steel sheet according to anyone of claims 8 to 15 or obtained through method of claims 1 to 7.
17. Vehicle including a structural part according to claim 16.

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2013/001708

A. CLASSIFICATION OF SUBJECT MATTER

INV. C21D8/04 C23C2/06 C23C2/26 C23C2/28 C23C2/40
C21D9/46 C21D1/18 C21D1/22 C21D1/25 C22C38/00

ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

C21D C23C C22C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EP0-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

8 April 2014

Date of mailing of the international search report

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INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2013/001708

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