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(54) **Title: COLD ROLLED HIGH STRENGTH LOW ALLOY STEEL**

(57) **Abrégé/Abstract:**

The invention relates to a high strength low alloy steel. According to the invention the high strength low alloy steel strip, sheet or blank, coated with zinc or a zinc alloy, has the following composition in weight%: C: 0.03 - 0.07, Mn: 0.70 - 1.60, Si: \leq 0.01 - 0.2, Al: 0.005 - 0.1, Cr: \leq 0.1, Cu: \leq 0.2, N: \leq 0.008, P: \leq 0.03, S: \leq 0.025, O: \leq 0.01, Ti: 0.02 - 0.07, V: 0.04 - 0.15, Mo: \leq 0.03, Nb: \leq 0.03, Ca: \leq 0.05, the remainder being iron and unavoidable impurities, wherein the steel strip, sheet or blank has a yield strength $R_{p0.2}$ of at least 420 MPa.

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(54) Title: COLD ROLLED HIGH STRENGTH LOW ALLOY STEEL

(57) Abstract: The invention relates to a high strength low alloy steel. According to the invention the high strength low alloy steel strip, sheet or blank, coated with zinc or a zinc alloy, has the following composition in weight%: C: 0.03 - 0.07, Mn: 0.70 - 1.60, Si: ≤ 0.01 - 0.2, Al: 0.005 - 0.1, Cr: ≤ 0.1, Cu: ≤ 0.2, N: ≤ 0.008, P: ≤ 0.03, S: ≤ 0.025, O: ≤ 0.01, Ti: 0.02 - 0.07, V: 0.04 - 0.15, Mo: ≤ 0.03, Nb: ≤ 0.03, Ca: ≤ 0.05, the remainder being iron and unavoidable impurities, wherein the steel strip, sheet or blank has a yield strength Rp0,2 of at least 420 MPa.



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COLD ROLLED HIGH STRENGTH LOW ALLOY STEEL

5 The invention relates to a high strength low alloy steel strip, sheet or blank. The invention also relates to a method for producing such a high strength low alloy steel strip.

High strength low alloy steel (HSLA steel) is well known in the art. HSLA steels are often used in the automotive industry. HSLA steels are for instance defined in the specification of the Verband Der Automobilindustrie (VDA). Reference is made to the VDA 239-100 Material specification of August 2011. According to the VDA, cold
10 rolled HSLA steels are indicated with a steel grade number, for instance CR420LA, wherein CR stands for cold rolled, the number 420 stands for the lower limit of the yield strength $R_{p0,2}$ in longitudinal direction, and LA stands for low alloy. The VDA specification gives a chemical composition for HSLA steels containing Ti and Nb, apart from the standard alloying elements C, Mn, Si and Al, to provide for the high strength.

15 Thin HSLA steel strip, sheet or blank is usually coated with an aluminium coating or a zinc coating. If a zinc coating is used, the coating is often applied as a hot dip galvanised or hot dip galvanized coating.

Cold rolled HSLA steels at higher strength levels have the drawback that, due to their high strength, the hot rolled strip is difficult to cold roll to a relatively thin gauge
20 at wide dimensions.

It is the object of the invention to provide a HSLA steel strip that can be cold rolled to a relatively thin gauge at wide dimensions, and made into HSLA sheets and blanks, having the required strength.

25 It is a further object of the invention to provide such a HSLA steel strip, sheet or blank having the required elongation.

It is another object of the invention to provide a method for producing such a HSLA steel strip.

30 According to the invention at least one of these objects is reached with a high strength low alloy steel strip, sheet or blank, coated with zinc or a zinc alloy, having the following composition in weight%:

C: 0.03 - 0.07,

Mn: 0.70 - 1.60,

Si: 0.01 - 0.2,

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Al: 0.005 - 0.1,

Cr: ≤ 0.1 ,

Cu: ≤ 0.2 ,

N: ≤ 0.008 ,

5 P: ≤ 0.03 ,

S: ≤ 0.025 ,

O: ≤ 0.01 ,

Ti: 0.02 - 0.07,

V: 0.04 - 0.15

10 Mo: ≤ 0.03 ,

Nb: ≤ 0.03 ,

Ca: ≤ 0.05 ,

the remainder being iron and unavoidable impurities,

wherein the steel strip, sheet or blank has a yield strength $R_{p0,2}$ of at least 420 MPa.

15 The inventors have found that when Ti and V are used as a combination of alloying elements, instead of the combination of Ti and Nb as known from the VDA specification, a steel is produced that provides lower mill loads. The Ti and V levels have to be used in combination with a specific level for C, Mn and Si, as specified according to the invention. Within the ranges of the invention, it is possible to achieve a
20 yield strength $R_{p0,2}$ of at least 420 MPa.

Preferably, the HSLA steel according to the invention contains no added Cr, Cu, Mo and Nb. These elements are not needed to provide a HSLA steel with the required yield strength.

25 Vanadium provides precipitation strengthening and some grain refinement. At a concentration lower than 0.04 wt% V the volume of vanadium-carbide precipitates is not sufficient to provide enough additional precipitation strengthening to reach a strength of 420 MPa for $R_{p0,2}$. At concentrations higher than 0.15 wt% V recrystallisation is suppressed during annealing. This limits elongation.

30 Titanium also provides precipitation strengthening and some grain refinement. At concentrations higher than 0.07 wt% Ti the work hardening during cold rolling will rise significantly, limiting a high cold reduction. On the other hand, the inventors have found that a concentration lower than 0.02 wt% Ti will decrease the total elongation of

the steel strip, sheet or blank. The combination of the right amount of Ti and V appears to generate a special microstructure providing both a high strength and elongation.

Carbon is useful to increase the solution strengthening and thus gain more strength. Therefore, at least 0.03 wt% C should be added. However a too high concentration will limit the cold rolling and will decrease the elongation. For this reason, the amount of carbon is limited to 0.07 wt%.

Manganese is also used for solution strengthening and has similar effect as C, but with less intensity. Therefore to respond to the strength increase a required minimum amount is 0.7 wt% Mn. Moreover a high addition will affect the surface quality and raises the cost. Therefore, the upper limit to be used is 1.60 wt% Mn.

Nitrogen has an effect similar to that of C. This element will combine preferentially with Al and Ti to form AlN and TiN precipitates. TiN precipitates are formed at high temperatures already in the re-heating oven, but also during hot rolling and during coiling. They are large precipitates (several microns) that do not increase the strength. AlN can also form at high temperature. Nevertheless with a fast cooling and a coiling temperature lower than 650 °C, their precipitation can be partly stopped, keeping in solid solution a source of Al and N that precipitates during the continuous annealing and that may contribute to the precipitation strengthening. If a large amount of N is added (>0.008wt%) elongation is degraded and cracking of slabs occurs.

Silicon is used for solution strengthening, but at a high concentration (>0.2 wt% Si) it will deteriorate the surface quality. The smelting cost to remove the Si becomes too high if the concentration is below 0.01 wt% Si.

Phosphorus is used for solution strengthening, but a high concentration will deteriorate the steel ductility. Therefore, the concentration should be below 0.03 wt% P.

Aluminium is used as deoxidizer in steel and its minimum amount should be 0.005 wt% Al to ensure the deoxidation. At a concentration higher than 0.1 wt% Al, the occurrence of surface defects resulting from alumina clusters increases.

Niobium is kept as low as possible and even avoided because it will increase significantly the work hardening and thus limit the cold reduction of wide strip. Moreover at a concentration higher than 0.03 wt% Nb, it has a great effect on the recrystallisation temperature which makes the use of a high annealing temperature necessary (higher than 800 °C) to obtain reasonably recrystallised HSLA.

Cr, Cu, S, O, Mo and Ca should all be low. For instance, a high S level will deteriorate the ductility of the steel, as is known in the art.

According to a preferred embodiment, one or more of the alloying elements can be present in a limited amount, as follows:

- 5 C: 0.04 - 0.06 and/or
 Mn: 0.80 - 1.40 and preferably Mn: 0.80 - 1.30 and/or
 Si: 0.01 - 0.1 and preferably Si 0.01 - 0.05 and/or
 Al: 0.015 - 0.055 and/or
 Cr: ≤ 0.05 and/or
 10 Cu: ≤ 0.05 and/or
 N: 0.002 - 0.008 and/or
 O: ≤ 0.005 and/or
 Ti: 0.02 - 0.06 and/or
 V: 0.05 - 0.15 and/or
 15 Mo: ≤ 0.01 and preferably $0 < Mo \leq 0.01$ and/or
 Nb: ≤ 0.02 and preferably Nb: ≤ 0.01 and/or
 Ca: ≤ 0.01 .

It is an aim of the invention to maximise the elongation at a given strength level and also an aim to roll as wide as possible for a given gauge at a given strength
 20 level.

Narrowing the Carbon range gives the best elongation for a given strength level. Increasing the minimum C level increases the proof stress of the material. Reducing the upper C level minimises cold rolling loads and achieves the best combination of maximum width and elongation at this higher strength level.

25 Manganese helps with recrystallisation as well as providing solid solution strengthening. By increasing the minimum level of Mn a better combination of strength and ductility is achieved. Too much Mn is bad for the surface condition and increases the chance of MnS stringers which can be deleterious to ductility. Hence reducing the maximum Mn level has benefits also. Reduced Silicon levels have benefits for surface
 30 quality.

Narrowing the Aluminium range improves the deoxidation and limits the risk on surface defects.

Titanium retards recrystallisation. Minimising the maximum Ti level can assist in optimising the elongation for a given strength level.

Vanadium retards recrystallisation. Minimising the maximum V level can assist in optimising the elongation for a given strength level.

5 Minimising the Niobium level further assist in being able to roll wider at a given strength level of the cold rolled and annealed product

Minimising the remaining elements further assist in improving elongation at a given strength level.

10 Preferably, the steel strip, sheet or blank has a yield strength $R_{p0,2}$ in longitudinal direction of at least 460 MPa, more preferably a yield strength $R_{p0,2}$ of at most 580 MPa. The automotive industry prefers to use HSLA steel having such a yield strength, in accordance with the VDA specification.

15 According to a preferred embodiment the steel strip, sheet or blank has an elongation A_{80mm} in longitudinal direction of at least 15%. This is the elongation a CR460LA steel grade should possess according to the VDA specification.

Preferably, the steel strip, sheet or blank has a tensile strength R_m in longitudinal direction of at least 480 MPa, more preferably a tensile strength R_m of at least 520 MPa, more preferably a tensile strength R_m of at most 680 MPa. These tensile strengths are preferred for by the automotive industry, in accordance with the VDA specification.

20 According to a preferred embodiment the zinc or zinc alloy coating is a hot dip galvanized or hot dip galvanized coating. These are the generally used zinc coatings in the automotive industry.

25 According to another preferred embodiment the zinc alloy coating comprises 0.5 to 4 wt% Al and 0.5 to 3.2 wt% Mg, the remainder being zinc and traces of other elements. The coating preferably has a thickness between 5 and 15 μm per side, more preferably a thickness between 6 and 13 μm per side. This is a so-called AlMgZn coating providing an improved corrosion protection in comparison to the usual zinc coatings. The other elements that can be present are Pb or Sb, Ti, Ca, Mn, Sn, La, Ce, Cr, Ni, Zr or Bi. Pb, Sn, Bi and Sb are usually added to form spangles. These elements
30 can be present in small amounts, less than 0.5 wt% each, usually less than 0.2 wt% each, often less than 0.2 wt% in total.

According to a second aspect of the invention there is provided a method for

producing a high strength low alloy steel strip comprising the following steps:

producing a molten steel having the composition according to the first aspect of the invention,

casting the molten steel in a casting apparatus,

5 hot rolling the casting with an end temperature of at least 880° C into a strip,

coiling the hot rolled strip at a coiling temperature between 500° C and 650° C,

cold rolling the strip with an overall reduction of 50 - 75%,

continuous annealing the strip at an annealing temperature between 750° C and 820° C.

10 Due to the coiling temperature, reduction rate and annealing temperature of the strip in accordance with the method of the second aspect of the invention, it is possible to provide the HSLA strip with the composition according to the first aspect of the invention with a yield strength $R_{p0,2}$ of at least 420 MPa.

The coiling temperature is affecting the precipitation of V and mainly VC. At 15 550 °C a small amount of VC is present that helps the cold rolling (less work hardening). At higher coiling temperatures, the volume of VC precipitates will increase, increasing the work hardening and thus making the cold rolling more difficult, which at the end will limit the width of the strip to be cold rolled at the defined cold reduction. Above 650 °C, the VC precipitates will start to coarsen and then the benefit of the 20 precipitation strengthening in the cold rolled annealed end material will be lowered. At coiling temperatures below 500°C there is a chance of bainite formation in the hot rolled coil. Bainite will increase cold rolling loads. It is preferential to avoid bainite, hence temperatures below 500°C are not recommended.

Concerning the cold reduction, in principle it is not a limiting factor as long as 25 one has powerful mills to cold roll up to 90%. Moreover, the higher is the cold reduction, the easier will be the recrystallisation of the grade .A high cold reduction will allow the use of a low annealing temperature.

There is thus a duality between the cold reduction percentage and the annealing temperature. As mentioned above a higher cold reduction will allow a lower annealing 30 temperature. The upper limit of the annealing temperature is governed by the coarsening/dissolution of VC precipitates. This upper limit should be at least 20 °C lower than the solubility temperature of VC precipitates. The solubility of VC

precipitates is depending on the V (and C) concentration. In counter part, the volume of VC precipitates will affect the recrystallisation of the steel; the greater the VC volume, the higher the recrystallisation temperature is.

For each variation of V concentration in the steel composition a balance should
5 be found between the cold rolling reduction and the concentration of C, Mn, N and Ti, in order to define a annealing temperature.

Preferably the annealed strip is hot dip coated with a zinc or zinc alloy coating. Usually the continuous annealing is directly followed by the hot dip coating with zinc or a zinc alloy.

10 According to a preferred embodiment the coated strip is cold rolled in a temper mill with a reduction of 0.1 - 3.0 %, preferably 0.2 - 2.0 %. The temper rolling provides the strip with an improved surface quality. At higher levels of temper rolling an increased yield strength is seen as well as the removal of yield point elongation (Luders lines).

15 Preferably, the strip is cold rolled at a width of at least 1400 mm, preferably at a width of at least 1600 mm, more preferably at a width of at least 1800 mm, with a gauge of 0.7 - 2.0 mm. This is possible because the HSLA with Ti and V has an improved ductility compared to HSLA with Ti and Nb or with Nb and V.

20 According to a preferred embodiment the coiling temperature of the hot rolled strip is between 550° C and 600° C and/or the overall cold rolling reduction is 60 - 70 % and/or the annealing temperature is between 760° C and 800° C. Using one or more of these limited ranges in the required steps provides optimum properties after cold rolling and galvanising, so as to achieve an optimal ductility. This makes it easier to cold roll to the required gauges and widths.

25 Preferably, the steel used in the method has a composition as provided by the preferred embodiment of the composition according to the first aspect of the invention.

According to a preferred embodiment the produced steel strip has a yield strength $R_{p0,2}$ of at least 420 MPa, preferably a yield strength $R_{p0,2}$ of at least 460 MPa, more preferably a yield strength $R_{p0,2}$ of at most 580 MPa.

30 Preferably, the produced steel strip has an elongation A_{80mm} of at least 15%.

The invention will be elucidated with reference to the following examples.

A number of strips has been produced as full production material. Samples of

these strips are indicated with the numbers 1, 2, 3 and 4. For each sample a variant A and B is tested, wherein the variants A and B each time have the same composition, see Table 1, but for which variants A and B different coiling temperatures and different temper rolling reductions are used. The information about the coiling temperature and temper rolling reduction, together with the cold reduction percentage and the annealing temperature, is given in Table 2.

Table 1: composition in wt%

Sample	C	Mn	P	S	Si	Al	Ti	V	Nb	Mo	N
1A	0,045	0,915	0,012	0,004	0,022	0,027	0,047	0,061	0	0,003	0,0039
1B	0,045	0,915	0,012	0,004	0,022	0,027	0,047	0,061	0	0,003	0,0039
2A	0,045	1,296	0,01	0,004	0,025	0,031	0,048	0,082	0,001	0,003	0,0047
2B	0,045	1,296	0,01	0,004	0,025	0,031	0,048	0,082	0,001	0,003	0,0047
3A	0,045	0,915	0,012	0,004	0,022	0,027	0,047	0,061	0	0,003	0,0039
3B	0,045	0,915	0,012	0,004	0,022	0,027	0,047	0,061	0	0,003	0,0039
4A	0,045	1,296	0,01	0,004	0,025	0,031	0,048	0,082	0,001	0,003	0,0047
4B	0,045	1,296	0,01	0,004	0,025	0,031	0,048	0,082	0,001	0,003	0,0047

Table 2 shows that for a composition in accordance with the invention it is possible to reach a yield strength $R_{p0,2}$ of at least 420 MPa for a cold reduction of 60 %, and with the right choice of composition, coiling temperature and annealing temperature it is even possible to reach a yield strength $R_{p0,2}$ of at least 460 MPa, see samples 2, 3 and 4. The temper rolling reduction for these samples has been at most 1 %.

Table 2 also shows that the elongation A_{80mm} is usually at least 15 % for the samples tested. Only for sample 4A, which has the highest yield strength $R_{p0,2}$, the elongation A_{80mm} is slightly lower than 15 %.

It should be mentioned here that for samples 1A - 2B the elongation A_{80mm} has been measured in rolling direction of the strip, but that for samples 3A - 4B the elongation has been measured in transverse direction of the strip. This explains to some extent why the elongation A_{80mm} is lower for samples 3A - 4B, though also a higher yield strength $R_{p0,2}$ usually implies a lower elongation A_{80mm} .

Table 2: processing values and resulting strength and elongation

Sample	Coiling Temp	Cold reduction	Annealing Temp	Temper Rolling	Rp0.2	Rm	A80
	(°C)	(%)	(°C)	(%)	(MPa)	(MPa)	(%)
1A	600	60	780	0,2	437	514	23,9
1B	550	60	780	1	422	524	20,1
2A	650	60	800	1	463	579	17,0
2B	550	60	800	0,1	460	568	19,9
3A	550	60	780	1	497	569	16,8
3B	600	60	780	1	495	571	15,4
4A	650	60	800	1	532	618	14,6
4B	550	60	800	1	501	590	17

Table 3 shows laboratory samples 5 and 6 from the same production material as used for sample 1A and 1B, which samples 5 and 6 have been processed with annealing temperatures near the limits or outside the range provided according to the invention.

Sample 5 shows that with an annealing temperature that is too high, the Rp0,2 will be too low. Sample 6 shows that when the annealing temperature is quite low, the elongation A80mm is lower than desired. Samples 5 and 6 thus show that the annealing temperature is quite critical for reaching the desired properties.

Table 3: processing values and resulting strength and elongation

Sample	Coiling Temp	Cold reduction	Annealing Temp	Temper Rolling	Rp0.2	Rm	A80
	(°C)	(%)	(°C)	(%)	(MPa)	(MPa)	(%)
5	550	60	830	0	402	450	24,4
6	550	60	760	0	627	527	12,2

As a comparison, a laboratory sample has been tested that contained more Ti than required according to the invention, but (almost) none V. The composition is shown in Table 4. The amount of P and S has not been measured, but these elements have not been added and thus fall in the limits given for this invention.

Table 4: comparative example

C	Mn	P	S	Si	Al	Ti	V	Nb	Mo	N
0,041	0,83	n/a	n/a	0,11	0,025	0,18	0,004	0	0,003	0,01

The processing conditions are given in Table 5. Though the annealing temperature chosen is above the upper limit according to the invention, this comparative example shows a very low yield strength Rp0,2, indicating that the use of Ti without V will not lead to the required yield strength.

Table 5: processing values and resulting strength and elongation for the comparative example

Coiling Temp	Cold reduction	Annealing Temp	Temper Rolling	Rp0.2	Rm	A50
(°C)	(%)	(°C)	(%)	(MPa)	(MPa)	(%)
600	60	850	0	215	405	30

10

A further number of strips has been produced as full production material as well. Samples of these strips are indicated with the number 1 when they have the same composition as sample 1 above. Other examples are indicated with sample 7 to 14. For sample 1 a variant C, D and E is tested, wherein the variants each time have the same composition, see Table 6, but for which variants different coiling temperatures and different temper rolling reductions are used. For sample 7, 8, 9 and 10 a variant A and B has been tested, wherein the variants A and B each time have the same composition, but in most cases a different coiling temperature, annealing temperature or temper rolling reduction is used. For samples 11 - 14 each time only one variant has been tested. The information about the coiling temperature and temper rolling reduction, together with the cold reduction percentage and the annealing temperature, is given in Table 7.

25

Table 6: composition in wt%

Sample	C	Mn	P	S	Si	Al	Ti	V	Nb	Mo	N
1C		0,915	0,012	0,004	0,022	0,027	0,047	0,061	0	0,003	0,0039
1D	0,045	0,915	0,012	0,004	0,022	0,027	0,047	0,061	0	0,003	0,0039
1E	0,045	0,915	0,012	0,004	0,022	0,027	0,047	0,061	0	0,003	0,0039
7A	0,062	0,892	0,013	0,003	0,028	0,032	0,049	0,105	0,001	0,006	0,0029
7B	0,062	0,892	0,013	0,003	0,028	0,032	0,049	0,105	0,001	0,006	0,0029
8A	0,05	0,88	0,01	0,003	0,02	0,034	0,051	0,103	0,001	0,006	0,0038
8B	0,05	0,88	0,01	0,003	0,02	0,034	0,051	0,103	0,001	0,006	0,0038
9A	0,057	0,891	0,014	0,003	0,03	0,037	0,045	0,063	0,001	0,005	0,0045
9B	0,057	0,891	0,014	0,003	0,03	0,037	0,045	0,063	0,001	0,005	0,0045
10A	0,047	0,909	0,015	0,003	0,021	0,036	0,053	0,062	0,001	0,004	0,0041
10B	0,047	0,909	0,015	0,003	0,021	0,036	0,053	0,062	0,001	0,004	0,0041
11	0,057	0,891	0,014	0,003	0,03	0,037	0,045	0,063	0,001	0,005	0,0045
12	0,047	0,909	0,015	0,003	0,021	0,036	0,053	0,062	0,001	0,004	0,0041
13	0,062	0,892	0,013	0,003	0,028	0,032	0,049	0,105	0,001	0,006	0,0029
14	0,05	0,88	0,01	0,003	0,02	0,034	0,051	0,103	0,001	0,006	0,0038

Table 7: processing values and resulting strength and elongation

Sample	Coiling Temp	Cold reduction	Annealing Temp	Temper Rolling	Rp0.2	Rm	A80
	(°C)	(%)	(°C)	(%)	(MPa)	(MPa)	(%)
1C	600	60	780	1	465	556	17,5
1D	550	60	780	0,5	460	547	25,0
1E	600	60	780	0,2	463	542	28,5
7A	540	65	790	1	466	572	16,2
7B	540	65	790	1	470	577	20,3
8A	560	65	790	1,4	463	565	18,9
8B	530	65	780	1,4	484	496	16,4
9A	543	65	783	1	458	561	20
9B	539	65	790	1	432	539	20,7
10A	530	65	770	1	441	547	20,1
10B	560	65	783	1	455	561	20,5
11	543	65	783	1	514	596	15,3
12	530	65	770	1	529	587	17,2
13	540	65	790	1	552	610	14
14	560	65	790	1,4	528	597	13,8

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Table 7 shows also that for a composition in accordance with the invention it is possible to reach a yield strength $R_{p0,2}$ of at least 420 MPa for a cold reduction of 60 or 65 %, and with the right choice of composition, coiling temperature and annealing temperature it is even possible to reach a yield strength $R_{p0,2}$ of at least 460 MPa, see samples 1C, 1D, 1E and samples 7A, 7B, 8A, 8B, 11, 12, 13 and 14. The temper rolling reduction for most of these samples has been at most 1 %; only for samples 8A, 8B and 14 the temper rolling reduction has been 1,4 %.

Table 7 also shows that the elongation A80mm is usually at least 15 % for the samples tested. Only for samples 13 and 14, which have a very high yield strength $R_{p0,2}$, the elongation A80mm is somewhat lower than 15 %.

It should be mentioned here that for samples 1C - 1E and 7A - 10B the elongation A80mm has been measured in rolling direction of the strip, but that for samples 11 - 14 the elongation has been measured in transverse direction of the strip. This explains to some extent why the elongation A80mm is lower for samples 11 - 14, though also a higher yield strength $R_{p0,2}$ usually implies a lower elongation A80mm.

In the compositions of table 1, 4 and 6 no molybdenum has been added. The amount of molybdenum mentioned in these tables is the amount of molybdenum present as residual element, thus as unavoidable impurity. Chromium and Copper are not mentioned in the tables 1, 4 and 6, and these elements have also not been added to the steel, but these elements are also present as residual element and thus as unavoidable impurity.

From the discussion of the steel composition above it is clear that Mo, Cr and/or Cu can be added to the steel.

CLAIMS

- 1 A steel strip, sheet or blank, coated with zinc or a zinc alloy, having the following composition in weight%:
 - C: 0.03 - 0.07,
 - Mn: 0.70 - 1.60,
 - Si: 0.01 - 0.2,
 - Al: 0.005 - 0.1,
 - Cr: ≤ 0.1 ,
 - Cu: ≤ 0.2 ,
 - N: ≤ 0.008 ,
 - P: ≤ 0.03 ,
 - S: ≤ 0.025 ,
 - O: ≤ 0.01 ,
 - Ti: 0.02 - 0.07,
 - V: 0.04 - 0.15,
 - Mo: ≤ 0.03 ,
 - Nb: ≤ 0.03 ,
 - Ca: ≤ 0.05 ,the remainder being iron and unavoidable impurities,
wherein the steel strip, sheet or blank has a yield strength $R_{p0,2}$ of at least 420MPa.
- 2 The steel strip, sheet or blank according to claim 1, wherein:
 - Mn: 0.80 - 1.40.
- 3 The steel strip, sheet or blank according to claim 2, wherein Mn: 0.80 - 1.30.
- 4 The steel strip, sheet or blank according to any one of claims 1 to 3, wherein the steel strip, sheet or blank has a yield strength $R_{p0,2}$ in longitudinal direction of at least 460 MPa.
- 5 The steel strip, sheet or blank according to claim 4, wherein the steel strip, sheet or blank has a yield strength $R_{p0,2}$ in longitudinal direction of at most 580 MPa.

- 6 The steel strip, sheet or blank according to any one of claims 1 to 5, wherein the steel strip, sheet or blank has an elongation A80mm in longitudinal direction of at least 15%.
- 7 The steel strip, sheet or blank according to any one of claims 1 and 4 to 5, wherein the steel strip, sheet or blank has a tensile strength Rm in longitudinal direction of at least 480 MPa.
- 8 The steel strip, sheet or blank according to claim 7, wherein the steel strip, sheet or blank has a tensile strength Rm in longitudinal direction of at least 520 MPa.
- 9 The steel strip, sheet or blank according to any one of claims 7 to 8, wherein the steel strip, sheet or blank has a tensile strength Rm in longitudinal direction of at most 680 MPa.
- 10 The steel strip, sheet or blank according to any one of claims 1 - 9, wherein the zinc or zinc alloy coating is a hot dip galvanized or hot dip galvanized coating.
- 11 The steel strip, sheet or blank according to any one of claims 1 - 10, wherein the zinc alloy coating comprises 0.5 to 4 wt% Al and 0.5 to 3.2 wt% Mg, the remainder being zinc and traces of other elements, the coating having a thickness between 5 and 15 μm per side.
- 12 The steel strip, sheet or blank according to claim 11, wherein the coating has a thickness between 6 and 13 μm per side.
- 13 A method for producing a steel strip, the method comprising the following steps:
 - producing a molten steel having the composition of claim 1,
 - casting the molten steel in a casting apparatus,
 - hot rolling the casting with an end temperature of at least 880° C into a strip,
 - coiling the hot rolled strip at a coiling temperature between 500° C and 650° C,
 - cold rolling the strip with an overall reduction of 50 - 75%,
 - continuous annealing the strip at an annealing temperature between 750° C and 820° C.
- 14 The method according to claim 13, wherein the annealed strip is hot dip coated with a zinc or zinc alloy coating.
- 15 The method according to claim 14, wherein the coated strip is cold rolled in a temper mill with a reduction of 0.1 - 3.0 %.

- 16 The method according to claim 15, wherein the coated strip is cold rolled in a temper mill with a reduction of 0.2 - 2.0 %.
- 17 The method according to any one of claims 13 to 16, wherein the strip is cold rolled at a width of at least 1400 mm, with a gauge of 0.7 - 2.0 mm.
- 18 The method according to claim 17, wherein the strip is cold rolled at a width of at least 1600 mm.
- 19 The method according to claim 18, wherein the strip is cold rolled at a width of at least 1800 mm.
- 20 The method according to any one of claims 13 to 19, wherein the coiling temperature of the hot rolled strip is between 550° C and 600° C and/or the overall cold rolling reduction is 60 - 70 % and/or the annealing temperature is between 760° C and 800° C.
- 21 The method according to any one of claims 13 - 20, wherein Mn: 0.80-1.40 in the steel.
- 22 The method according to claim 21, wherein Mn: 0.80 - 1.30 in the steel.
- 23 The method according to any one of claims 13 - 22, wherein the produced steel strip has a yield strength $R_{p0,2}$ of at least 420 MPa, .
- 24 The method according to claim 23, wherein the produced steel strip has a yield strength $R_{p0,2}$ of at least 460 MPa.
- 25 The method according to any one of claims 23 to 24, wherein the produced steel strip has a yield strength $R_{p0,2}$ of at most 580 MPa.
- 26 The method according to any one of claims 13- 25, wherein the produced steel strip has an elongation A_{80mm} of at least 15%.