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(54) **A STRIP OF STEEL HAVING A VARIABLE THICKNESS IN LENGTH DIRECTION**

METALLSTREIFEN MIT VERÄNDERLICHER DICKE IN LÄNGSRICHTUNG

BANDE MÉTALLIQUE D'ÉPAISSEUR VARIABLE À LA LONGUEUR

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Description

[0001] The invention relates to a strip of steel having a variable thickness in its length direction with at least thicker and thinner sections, the strip having been cold rolled to form the thicker and thinner sections, one thicker and one thinner section having a length of at most a few metres. as defined by the corresponding claims. A strip of steel having a variable thickness in its length direction is often made such that the strip has a repetitive thickness variation, wherein a thicker section of the strip is followed by a thinner section which is thereafter followed by a thicker section, and this is repeated over the length of the strip. Often the thinner sections all have approximately the same length, and so have the thicker sections. One thicker and one thinner section have a length of at most a few metres. One strip can have at least a few hundred thicker and thinner sections. The thicker and thinner sections have a thickness between a few tenths of a millimetre and a few millimetres. For special purposes, the strip is rolled into three or more different thicknesses which repeat along the length of the strip. Due to the fact that the strip of steel has been cold rolled, between the thicker and thinner sections a transitional section will be formed in which the thickness of the strip gradually changes from the thickness of one section to the thickness of the following section. The length of this transitional section is determined by the thickness change between the sections, the rolling speed and the speed with which the cold rolling mill can change the distance between the rolls, to mention the most important parameters. Usually, the length of the transitional section is of the same order as the length of the thicker and thinner sections or even shorter. The width of the strip can be from a few decimetre up to about two meter. The strip can be slit into two or more strips having a reduced width, but this is not always required. Such a strip is cut into pieces which are called tailor rolled blanks (TRBs), for instance for the automotive industry. The blanks thus have at least two different thicknesses over their lengths, as required for the purpose and place they are used in.

[0002] During the rolling of the strip of steel the thickness is considerably reduced in the thinner portions. This results in a hardening of the steel, such that the rolled strip cannot be used directly. The steel strip has to be annealed to release the stresses in the strip and/or to recrystallise the strip.

[0003] Annealing of a steel strip without thickness variations can be performed either by batch annealing or by continuous annealing. Annealing of steel strip having a variable thickness in its length direction, however, is performed only by batch annealing, so as to provide the same temperature to both the thinner and the thicker sections. Batch annealing though is more expensive than continuous annealing, and it usually has a somewhat deteriorating effect on the strength of the steel. Due to the slow heating and cooling rate experienced in the case of batch annealing it is not attractive for all steel types, especially for steel types having a higher strength.

[0004] It is an object of the invention to provide an improved strip of steel having a variable thickness in its length direction with at least thicker and thinner sections.

[0005] It is another object of the invention to provide a strip of steel having a variable thickness in its length direction that is more cost-efficient than a batch annealed strip.

[0006] It is a further object of the invention to provide a strip of steel that provides a higher strength as compared to a batch annealed strip.

[0007] It is still another object of the invention to provide tailor rolled blanks produced from such strips of steel.

[0008] According to the invention at least one of these objects is reached using a strip of steel having a variable thickness in its length direction with at least thicker sections and thinner sections, the strip having been cold rolled to form the thicker and thinner sections, one thicker and one thinner section having a length of at most a few meter, which strip has been annealed, wherein the annealing is performed by continuous annealing. as defined by the corresponding claims on file. The inventors of the present invention have observed that, contrary to the well-known batch annealing which is the only method of annealing used for strip having a variable thickness according to the state of the art, it is nevertheless possible to continuous anneal a strip of steel having a variable thickness in length direction. Continuous annealing has the advantage that it is a faster process and provides new and better tailor rolled blanks. Tailor rolled blanks produced using continuous annealing have better mechanical properties than tailor rolled blanks produced using batch annealing having the same composition and rolling history, such as a higher mechanical strength, and so have the strips of steel from which such tailor rolled blanks are produced.

[0009] With batch annealing a strip having a variable thickness will have different mechanical properties in the different sections because of the variation in cold rolling reduction, whereas the annealing temperature and heating rate will be the same in all sections. In the thinner sections a higher cold rolling reduction will produce different mechanical properties, for instance a higher yield strength. The advantage of continuous annealing over batch annealing is that with continuous annealing the sections with a variable thickness will also experience different temperatures and heating rates. In a thinner section the temperature will reach higher values than in a thicker section. The higher annealing temperature experienced in the thinner sections will reduce the strength, which partly or completely compensates the effect of the higher cold rolling reduction.

[0010] Preferably, the yield strength of the thicker sections is equal to or higher than the yield strength of the thinner sections. This is advantageous because the TRBs made from such strips are used for parts that need to have more

strength in the thicker section than in the thinner section.

[0011] According to a first preferred embodiment the steel strip is a DP, TRIP or multi phase high strength steel. These high strength steels can not be produced using batch annealing, so continuous annealing makes the use of DP, TRIP and multi phase high strength steels possible for producing strip having a variable thickness and the TRBs made thereof.

[0012] According to a second preferred embodiment the steel strip is a HSLA steel or a low carbon steel. Using continuous annealing for these steel types provides strip having a variable thickness and TRBs made thereof that have better mechanical properties, such as a higher yield strength.

[0013] When the strip of steel is a HSLA steel or low carbon steel, preferably only the thinner sections are recrystallised and the difference in yield strength of the thicker and thinner sections is smaller than in the same HSLA or low carbon steel strip that has been batch annealed. The recrystallised thinner sections reach a higher temperature due to the continuous annealing, compared to batch annealing, and therefore the thinner sections have for instance a higher yield strength. Thus, the yield strengths of the thicker and thinner sections have values that are more near to each other than the corresponding values of batch annealed strip having the same composition.

[0014] Preferably, the composition of the steel has lower values of alloying elements than in a batch annealed HSLA or low carbon steel having the same yield strength of the thinner sections. Since the yield strength is better for continuous annealed strip having a variable thickness than for batch annealed strip with the same composition, it is possible to provide strip having a variable thickness with the same yield strength as batch annealed strip, using a continuous annealed strip having lower values of alloying elements (which strip, when batch annealed, would have a lower yield strength). Thus, the steel strip having a variable thickness is cheaper.

[0015] According to the present invention the steel has the following composition in wt%:

C	0.03 to 0.08
Mn	0.1 to 1.2
Si	≤ 1.0
P	≤ 0.1
Nb	≤ 0.07
V	≤ 0.5
Ti	≤ 0.1

the remainder being iron and inevitable impurities. This is a normal composition for a low carbon steel, wherein the steel can contain one or more of the optional alloying elements Si, P, Nb, V and Ti. Such a steel composition for continuous annealed strips for vehicle bodies is disclosed in EP-A 1 571 229. The steel contains C, Mn, and optionally Si, P, Nb, V, and Ti, the remainder being iron and inevitable impurities, and is characterised by the equation:

$$YS \geq 250 + 225(Mn/6 + Si/24) + 716P + 2938Nb + 600V + 2000Ti \text{ [MPa]}$$

with Mn, Si, P, Nb, V, Ti in wt% and YS being the yield strength in the thinner sections of the strip. This equation shows that by using continuous annealing a high yield strength can be achieved in the thinner sections of the strip with less alloying elements than would be needed when such a strip had been batch annealed.

[0016] More preferably, the steel is characterised by the equation $YS \geq 270 + 225(Mn/6 + Si/24) + 716P + 2938Nb + 600V + 2000Ti$ [MPa]. Due to optimised process conditions for the continuous annealing, the steel strip having a variable thickness will reach the higher yield strength according to this equation.

[0017] Preferably, the strip of steel is characterised by the equation

$$A80 \geq -0.05 \cdot YS + 40$$

with A80 being the total elongation in the thinner sections of the strip and YS being the yield strength in the thinner sections of the strip. This equation shows that continuous annealed strip having a variable thickness will have product properties that are often required, that is a high total elongation combined with a high yield strength. A high total elongation is for instance required for stamping parts.

[0018] According to a further preferred embodiment the steel in the thinner sections has a tensile strength above 600 MPa and a yield strength below 400 MPa. The steel of this strip is for instance a dual phase steel that has been temper rolled.

[0019] More preferably the steel in the thinner sections has a tensile strength above 600 MPa and a yield strength

below 300 MPa. The lower yield strength is reached by an optimised rolling schedule before and/or after the continuous annealing of the strip.

[0020] According to a still further preferred embodiment the steel in the thinner sections has a tensile strength above 800 MPa and a yield strength below 550 MPa. The steel of this strip can be a dual phase steel as well, having a composition with higher amounts of alloying elements, which has been temper rolled.

[0021] More preferably the steel in the thinner sections has a tensile strength above 800 MPa and a yield strength below 450 MPa. Here too, the lower yield strength is reached by an optimised rolling schedule before and/or after the continuous annealing of the strip.

[0022] According to again a further preferred embodiment, the steel in the thinner sections has a tensile strength above 980 MPa and a yield strength below 750 MPa. Here as well, the steel can be a dual phase steel, having a composition having still higher amounts of alloying elements, which has been temper rolled.

[0023] More preferably the steel in the thinner sections has a tensile strength above 980 MPa and a yield strength below 650 MPa. Again, the lower yield strength is reached by an optimised rolling schedule before and/or after the continuous annealing of the strip.

[0024] According to a second aspect of the invention there is provided a tailor rolled blank produced from a strip of steel according to the description above. The tailor rolled blanks are cut from the strip having a variable thickness, and these tailor rolled blanks are used in the automotive industry, for instance.

[0025] The method according to the invention will be elucidated referring to the figures and examples below.

Figure 1 shows a schematic representation of a continuous annealing time-temperature cycle;

Figure 2 shows a schematic representation of the differences in temperature, heating and cooling rates between thin and thick sections of the TRB;

Figure 3 shows a schematic representation of the use of selective heating to adjust the differences in temperature, heating and cooling rates between thin and thick sections of the TRB.

Figure 4 shows a comparison between the yield strength measured for a number of steel types that are batch annealed and continuous annealed.

[0026] In the figures 1, 2 and 3 the temperature T is presented along the vertical axis and time t along the horizontal axis.

[0027] In figure 1 a typical continuous annealing time-temperature curve is presented. The process in a continuous annealing line for steel strip often consists of a sequential of different heating and cooling sections. As shown schematically in figure 1 normally a fast heating section (H1) is followed by a slow heating section (H2), after which the strip reaches its maximum temperature. This maximum temperature is normally higher than the recrystallisation temperature to ensure complete recrystallisation of the microstructure of the steel. In the case of high strength steels such as DP, TRIP and multi-phase high-strength steels the maximum temperature must be higher than 720 °C to bring the material in the two-phase region of austenite and ferrite. The presence of austenite, which can transform into martensite, bainite and/or retained austenite on subsequent cooling, is a prerequisite to produce high strength steels such as DP, TRIP and multi phase high strength steels. After realising the maximum temperature the strip can be cooled down, which is often done in several cooling sections. In figure 1 a slow cooling section (C1), a fast cooling section (C2) and a final cooling section (C3) are presented. The cooling of the strip can be interrupted for applying a metal coating process (MC), e.g. hot dip galvanising. After cooling of the strip temper rolling and/or other surface and/or shape modifications can be performed in line. The whole process normally takes less than 1000 seconds to complete.

[0028] In Figure 2 the effect of continuous annealing on TRB is illustrated. The sections with variation in thickness will show a difference in heating and cooling rates, and as a result will follow different time-temperature cycles. The line S1 indicates the time-temperature cycle for the thinner sections of the TRB, and the line S2 indicates the time-temperature cycle for the thicker sections of the TRB. Obviously the exact time-temperature profile depends on many parameters, such as the thickness profile of the strip, line speed, width of the strip, heating and cooling capacity of individual sections in the continuous annealing line. Noteworthy in figure 2 is the relatively large difference in temperature at the end of the fast heating section ($\Delta T1$). The difference $\Delta T1$ can in some cases reach values of more than 100 °C.

[0029] The difference in temperature at maximum temperature ($\Delta T2$) is a critical parameter for successfully producing continuous annealed TRB. If $\Delta T2$ becomes too big the mechanical properties of the thicker and/or thinner sections become unstable. If the temperature of the thicker sections becomes too low than the material is not fully recrystallised and the mechanical properties, especially the elongation, are not fully developed and extremely sensitive to small fluctuations of the maximum temperature. On the other hand, if the temperature of the thinner sections becomes too high, higher than 800 °C, the mechanical properties of especially high strength steels will deteriorate. The deterioration is caused by the fact that the grain size will increase with the maximum temperature, because the fine grain size after cold rolling and recrystallisation will be eliminated by transformation. With higher temperatures, above 720 °C, more austenite is formed and a larger fraction of the microstructure will after continuous annealing consist of transformed material instead of recrystallised material. This effect becomes especially detrimental above 800 °C because of the

increase in austenite fraction. In the case of high strength steels such as DP, TRIP and multi-phase high-strength steels a large temperature difference (ΔT_2) is undesirable because the mechanical properties are directly related to the maximum temperature, i.e. the amount of austenite before cooling.

[0030] The difference in temperature between the thicker and thinner sections of the TRB during cooling (ΔT_3 or ΔT_4) is also of importance. Especially if a metal coating process like hot dip galvanising is applied. When the strip entering the zinc bath is too cold, the zinc will not make good contact with the strip surface and problems with zinc adherence and surface quality will arise. The zinc only starts to solidify below a temperature of 420 °C. When the temperature of the strip entering the zinc bath is too high, the amount of iron dissolving in the zinc increases and thus the amount of metallic dross formation in the zinc bath. This can lead to a bad surface quality of the material. A high strip temperature can cause increased alloying between the zinc layer and the substrate.

[0031] According to a preferred embodiment the temperature differences between the thick and thin sections of the TRB can be reduced by selective heating. This is illustrated in figure 3. At some point during heating of the strip the temperature of the thicker sections is increased (H3). The temperature of the thicker sections can be increased to a temperature level reaching that of the thin section, or even above. In this way the difference in maximum temperature (ΔT_2) can be reduced significantly.

[0032] Hereinafter four examples of the annealing tailor rolled blanks are given. The chemical composition of the four examples is given in Table 1. The mechanical properties, after both batch and continuous annealing, are given in Table 2.

Table 1 Chemical composition*

example	C	Mn	P	S	Si	Al	N	Nb	V	Cr
	wt-%*10 ⁻³						ppm	wt-%*10 ⁻³		
1	39	276	13	6	22	27	31	14		
2	42	220	13	4	25	30	30			
3	51	250	8	4	8	40	26	27		
4	90	1700	15	5	260	45	31			550
* remainder being iron and inevitable impurities										

Example 1

[0033] A steel strip is formed by hot rolling. After hot rolling, a steel strip having a variable thickness in length direction is formed by cold rolling both the thicker sections and the thinner sections with a reduction of at least 15%. As a result, both the thicker and the thinner sections will recrystallise during annealing.

[0034] When continuous annealing is performed the strength of the TRB will always be higher than when batch annealing is applied. After continuous annealing the yield strength in the thick section is higher than in the thin section. In case of example 1 selective heating was not applied. The line speed in the continuous line was relatively low and therefore in this case the difference in temperature between the thin and the thick section is relatively small.

Example 2

[0035] A steel strip is formed by hot rolling. After hot rolling, a steel strip having a variable thickness in length direction is formed by cold rolling the thicker sections with a reduction of less than 15%, usually approximately 5%, and by cold rolling the thinner sections with a reduction of at least 15%, usually between 20 and 50%.

[0036] This rolling type has the advantage that in the thicker sections the hot rolled yield strength is increased by a small cold rolling reduction, which improves the yield strength, which is to a large extent retained during subsequent annealing. Another advantage is that cold rolling of the thinner sections is more easy because only the thinner sections have to be reduced.

[0037] The yield strength of the continuous annealed strip in the thinner sections is 73 MPa higher than for the batch annealed product. Also the yield strength in the thicker sections is higher after continuous annealing. Producing TRB by only applying a large reduction to the thinner sections is a production route that has many economical advantages. In case of batch annealing the inhomogeneity of the mechanical properties between the thinner and thicker sections is a problem. The advantage of a high yield strength in the thicker sections, based on the mechanical properties in hot rolled condition, can not be utilised fully in case of batch annealing because the yield strength in the thinner sections will always be much lower. In case of continuous annealing the yield strength in the thinner sections will come much closer to the yield strength in the thicker sections, with as result a TRB with better and more homogeneous mechanical properties.

Table 2 Mechanical properties

Example	section	Thickness [mm]	Cold rolling reduction [%]	Annealing method	Maximum annealing temp [°C]	Selective heating	Yield strength [MPa]	Tensile strength [MPa]	Total elongation [%]	remarks
1	Thin	0.6	70	Batch	640		310	395	35	comparison
1	Thick	1	50	Batch	640		300	385	34	comparison
1	Thin	0.6	70	Continuous	767	no	354	402	32	invention
1	Thick	1	50	Continuous	745	no	387	421	31	invention
2	Thin	0.65	57	Batch	640		264	334	32	comparison
2	Thick	1.45	4	Batch	640		336	389	32	comparison
2	Thin	0.65	57	Continuous	777	no	337	381	34	invention
2	Thick	1.45	4	Continuous	765	no	386	427	29	invention
3	Thin	0.75	70	Continuous	840	no	367	396	27	comparison
3	Thick	1.6	35	Continuous	740	no	463	511	14	comparison
3	Thin	0.75	70	Continuous	825	yes	372	406	27	invention
3	Thick	1.6	35	Continuous	794	yes	384	422	24	invention
4	Thin	1.0	60	Continuous	820	yes	254	612	22	invention
4	Thick	1.8	25	Continuous	780	yes	296	635	24	invention

[0038] Also in case of example 2 selective heating was not applied. The line speed in the continuous line was relatively low and therefore in this case the difference in temperature between the thinner and the thicker section is relatively small.

Example 3

[0039] Line speed in a continuous annealing line is important economical parameter. If line speed is low than cooling devices like gas jet cooling have to be operated at minimum capacity, outside the normal operation modus, making it more difficult to control the strip temperature before hot dip galvanising. Producing TRB with a normal line speed is both for economical and practical reasons beneficial. Selective heating is an effective method to enable the producer to increase line speed and at the same time improve the mechanical properties of the TRB.

[0040] In example 3, as comparison, a high strength steel is processed with a line speed of 50 m/min. It can be seen that the temperature in the thicker sections is too low to ensure complete recrystallisation. As a result the mechanical properties are insufficient, see e.g. the low total elongation of only 14%. With selective heating it is possible increase the temperature of thicker section to above the crystallisation temperature. In this way it is possible to improve the mechanical properties of the thicker sections without raising the temperature of the thinner sections. The temperature of the thinner section is well above 800 °C, raising the temperature of the thinner sections would lead to a deterioration of strength so selective heating is effective method to produce a TRB with reasonable line speed.

Example 4

[0041] In example 4 a dual phase steel is presented. Essential for producing dual phase kind of steel types is a high annealing temperature (in two phase region) and relatively high cooling rate to promote transformation from austenite to martensite, bainite and/or retained austenite. In case of dual phase steel a low line speed is a disadvantage because also the cooling rate will be slow.

[0042] As with example 3 selective heating is an effective method to be able to produce a TRB where both the thicker and the thinner sections reach a sufficient high temperature, without over-heating the thinner sections, in combination with a sufficient high line speed. Chemical composition and the mechanical properties, after continuous annealing, are given in Table 1 and Table 2. The mechanical properties are clearly in accordance with dual phase standards, i.e. ratio between tensile strength and yield strength is more than 2.

[0043] Figure 4 shows a comparison between the batch annealing and the continuous annealing for a number of low carbon steel types, of which the composition is given in table 3. The Yield Strength (YS) in the sections that are significantly reduced by cold rolling is given on the vertical axis, on the horizontal axis the different steel types are indicated. Such steel types are normal steel types that are produced and on the market. From Figure 4 it is clear that the yield strength of continuous annealed steel is significantly higher than the yield strength of the same steel types that are batch annealed. Such improved yield strengths are also reached in the thinner sections of a strip of steel having a variable thickness when it is continuous annealed instead of batch annealed, as elucidated in the examples above.

[0044] From Figure 4 it also becomes apparent that for a certain yield strength a batch annealed Nb3 type steel, having a yield strength of 310 MPa, can be replaced by a continuous annealed Nb1 steel type, which also has a yield strength of 310 MPa, or a LC steel type. This of course leads to a cheaper product, because less alloying elements are needed and cold rolling is easier.

[0045] Figure 4 contains a thick line, connecting the points of the calculated values using the equation $YS = 250 + 225(Mn/6 + Si/24) + 716P + 2938Nb + 600V + 2000Ti$ for the steel types with the composition as mentioned in table 3, in the sections that are significantly reduced by cold rolling. It will be clear that the yield strength as measured for the continuous annealed steel types is higher than the calculated yield strength, whereas the values as measures on the batch annealed steel types is lower. The calculated values thus give a good indication of the yield stress that will at least be reached for a continuous annealed steel type with a certain composition.

[0046] The elements indicated in table 3 that are present below a certain amount are inevitable impurities.

Table 3 Typical composition (in wt%) of different steel types

Steel type	C	Mn	Si	P	Nb	V
LC	0.045	0.22	<0.01	<0.01	<0.002	<0.002
Nb1	0.045	0.25	<0.01	<0.01	0.009	<0.002
Nb2	0.06	0.25	<0.01	<0.01	0.017	<0.002
P	0.06	0.5	<0.01	0.085	<0.002	<0.002

(continued)

Steel type	C	Mn	Si	P	Nb	V
V	0.045	0.8	<0.01	<0.01	0.013	0.04
Nb3	0.07	0.5	<0.01	<0.01	0.026	<0.002
Nb4	0.075	1	0.3	<0.01	0.03	<0.002

Claims

1. Strip of steel having a variable thickness in its length direction with at least thicker sections and thinner sections with a transitional section in between such that the strip has a repetitive thickness variation, the strip having been cold rolled to form the thicker and thinner sections, one thicker and one thinner section having a length of at most a few meter, which strip has been annealed, wherein the strip is to be cut into pieces called tailor rolled blanks, **characterised in that** the steel has the following composition in wt%:

C	0.03 to 0.08
Mn	0.1 to 1.2
Si	≤ 1.0
P	≤ 0.1
Nb	≤ 0.07
V	≤ 0.5
Ti	≤ 0.1

the remainder being iron and inevitable impurities, wherein the annealing has been performed by continuous annealing and wherein

$$YS \geq 250 + 225(Mn/6 + Si/24) + 716P + 2938Nb + 600V + 2000Ti \text{ [MPa]}$$

with Mn, Si, P, Nb, V, Ti in wt% and YS being the yield strength in the thinner sections of the strip.

2. Strip of steel according to claim 1, wherein the yield strength of the thicker sections is equal to or higher than the yield strength of the thinner sections.
3. Strip of steel according to claim 1 or 2, wherein only the thinner sections are recrystallised and wherein the difference in yield strength of the thicker and thinner sections is smaller than in the same HSLA or low carbon steel strip that has been batch annealed.
4. Strip of steel according to one or more of claims 1-3 4, wherein

$$YS \geq 270 + 225(Mn/6 + Si/24) + 716P + 2938Nb + 600V + 2000Ti \text{ [MPa]}$$

5. Strip of steel according to any one of the claims 1-4, wherein

$$A80 \geq -0.05 \cdot YS + 40$$

with A80 being the total elongation in the thinner sections of the strip and YS being the yield strength in the thinner sections of the strip.

6. Strip of steel according to claim 1, wherein the steel in the thinner sections has a tensile strength above 600 MPa and a yield strength below 400 MPa.

7. Strip of steel according to claim 6, wherein the steel in the thinner sections has a tensile strength above 600 MPa and a yield strength below 300 MPa.
8. Strip of steel according to claim 1, wherein the steel in the thinner sections has a tensile strength above 800 MPa and a yield strength below 550 MPa.
9. Strip of steel according to claim 8, wherein the steel in the thinner sections has a tensile strength above 800 MPa and a yield strength below 450 MPa.
10. Strip of steel according to claim 1, wherein the steel in the thinner sections has a tensile strength above 980 MPa and a yield strength below 750 MPa.
11. Strip of steel according to claim 10, wherein the steel in the thinner sections has a tensile strength above 980 MPa and a yield strength below 650 MPa.
12. Tailor rolled blank produced from a strip of steel according to any one of the preceding claims.

Patentansprüche

1. Stahlband mit variabler Dicke in Längsrichtung mit mindestens dickeren Abschnitten und dünneren Abschnitten mit einem Übergangsabschnitt dazwischen, so dass das Band eine sich wiederholende Dickenvariation aufweist, wobei das Band kaltgewalzt worden ist, um die dickeren und dünneren Abschnitte zu bilden, wobei ein dickerer und ein dünnerer Abschnitt eine Länge von höchstens ein paar Metern aufweist, wobei das Band gegläht wurde, wobei das Band in Stücke zu schneiden ist, die maßgewalzte Platinen ("tailor rolled blanks") genannt werden, **dadurch gekennzeichnet, dass** der Stahl die folgende Zusammensetzung in Gew.-% aufweist:

C	0,03 bis 0,08
Mn	0,1 bis 1,2
Si	≤ 1,0
P	≤ 0,1
Nb	≤ 0,07
V	≤ 0,5
Ti	≤ 0,1

wobei der Rest Eisen und unvermeidliche Verunreinigungen ist, wobei das Glühen durch kontinuierliches Glühen erfolgt ist und wobei gilt

$$YS \geq 250 + 225(Mn/6 + Si/24) + 716P + 2938Nb + 600V + 2000Ti \text{ [MPa]},$$

mit Mn, Si, P, Nb, V, Ti in Gew.-% und wobei YS die Streckgrenze in den dünneren Abschnitten des Streifens ist.

2. Stahlband nach Anspruch 1, wobei die Streckgrenze der dickeren Abschnitte gleich oder höher als die Streckgrenze der dünneren Abschnitte ist.
3. Stahlband nach Anspruch 1 oder 2, wobei nur die dünneren Abschnitte rekristallisiert sind und wobei der Unterschied in der Streckgrenze der dickeren und dünneren Abschnitte kleiner ist als im gleichen HSLA-oder kohlenstoffarmen Stahlband, der in Chargen gegläht wurde.
4. Stahlband nach einem oder mehreren der Ansprüche 1 bis 3, wobei gilt

$$YS \geq 270 + 225(Mn/6 + Si/24) + 716P + 2938Nb + 600V + 2000Ti \text{ [MPa]}.$$

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5. Stahlband nach einem der Ansprüche 1 bis 4, wobei gilt

$$A80 \geq -0,05 \cdot YS + 40$$

wobei A80 die Gesamtdehnung in den dünneren Abschnitten des Bands ist und YS die Streckgrenze in den dünneren Abschnitten des Bands ist.

6. Stahlband nach Anspruch 1, wobei der Stahl in den dünneren Abschnitten eine Zugfestigkeit über 600 MPa und eine Streckgrenze unter 400 MPa aufweist.
7. Stahlband nach Anspruch 6, wobei der Stahl in den dünneren Abschnitten eine Zugfestigkeit über 600 MPa und eine Streckgrenze unter 300 MPa aufweist.
8. Stahlband nach Anspruch 1, wobei der Stahl in den dünneren Abschnitten eine Zugfestigkeit über 800 MPa und eine Streckgrenze unter 550 MPa aufweist.
9. Stahlband nach Anspruch 8, wobei der Stahl in den dünneren Abschnitten eine Zugfestigkeit über 800 MPa und eine Streckgrenze unter 450 MPa aufweist,
10. Stahlband nach Anspruch 1, wobei der Stahl in den dünneren Abschnitten eine Zugfestigkeit über 980 MPa und eine Streckgrenze unter 750 MPa aufweist.
11. Stahlband nach Anspruch 10, wobei der Stahl in den dünneren Abschnitten eine Zugfestigkeit über 980 MPa und eine Streckgrenze unter 650 MPa aufweist.
12. Maßgewalzte Platine ("tailor rolled blank"), die aus einem Stahlband nach einem der vorherigen Ansprüche hergestellt ist.

Revendications

1. Bande d'acier ayant une épaisseur variable dans le sens de la longueur avec au moins des sections plus épaisses et des sections plus fines et avec une section transitoire comprise entre de telle sorte que la bande a une variation d'épaisseur répétitive, la bande ayant été laminée à froid pour former les sections plus épaisses et les sections plus fines, une section plus épaisse et une section plus fine ayant une longueur d'au moins quelques mètres, laquelle bande ayant été recuite, la bande devant être coupée en morceaux appelés ébauches laminées sur mesure ("tailor rolled blanks"), **caractérisée en ce que** la bande a la composition suivante, en % en poids :

C	0,03 à 0,08
Mn	0,1 à 1,2
Si	≤ 1,0
P	≤ 0,1
Nb	≤ 0,07
V	≤ 0,5
Ti	≤ 0,1

le reste étant du fer et des impuretés inévitables, le recuit ayant été réalisé par un recuit continu et

$$YS \geq 250 + 225 (Mn/6 + Si/24) + 716P + 2938Nb + 600V + 2000Ti \quad [MPa]$$

Mn, Si, P, Nb, V, Ti étant en % en poids et YS étant la limite d'élasticité des sections plus fines de la bande.

2. Bande d'acier selon la revendication 1, dans laquelle la limite d'élasticité des sections plus épaisses est identique

ou supérieure à la limite d'élasticité des sections plus fines.

3. Bande d'acier selon la revendication 1 ou 2, dans laquelle seules les sections plus fines sont recristallisées et dans laquelle la différence en termes de limite d'élasticité des sections plus épaisses et plus fines est plus petite que dans la même bande d'acier à faible teneur en carbone ou d'HSLA qui a été recuite de manière discontinue.

4. Bande d'acier selon une ou plusieurs des revendications 1 à 3, dans laquelle

$$Y_S \geq 270 + 225 \left(\frac{Mn}{6} + \frac{Si}{24} \right) + 716P + 2938Nb + 600V + 2000Ti \quad [MPa] .$$

5. Bande d'acier selon une ou plusieurs des revendications 1 à 4, dans laquelle

$$A_{80} \geq -0,05 \cdot Y_S + 40$$

A₈₀ étant l'élongation totale des sections les plus fines de la bande et Y_S étant la limite d'élasticité des sections les plus fines de la bande.

6. Bande d'acier selon la revendication 1, dans laquelle l'acier dans les sections plus fines a une résistance à la traction supérieure à 600 MPa et une limite d'élasticité inférieure à 400 MPa.

7. Bande d'acier selon la revendication 6, dans laquelle l'acier dans les sections plus fines a une résistance à la traction supérieure à 600 MPa et une limite d'élasticité inférieure à 300 MPa.

8. Bande d'acier selon la revendication 1, dans laquelle l'acier dans les sections plus fines a une résistance à la traction supérieure à 800 MPa et une limite d'élasticité inférieure à 550 MPa.

9. Bande d'acier selon la revendication 8, dans laquelle l'acier dans les sections plus fines a une résistance à la traction supérieure à 800 MPa et une limite d'élasticité inférieure à 450 MPa.

10. Bande d'acier selon la revendication 1, dans laquelle l'acier dans les sections plus fines a une résistance à la traction supérieure à 980 MPa et une limite d'élasticité inférieure à 750 MPa.

11. Bande d'acier selon la revendication 10, dans laquelle l'acier dans les sections plus fines a une résistance à la traction supérieure à 980 MPa et une limite d'élasticité inférieure à 650 MPa.

12. Ébauche enroulée sur mesure ("tailor rolled blank") produite à partir d'une bande d'acier selon l'une quelconque des revendications précédentes.

Fig. 1

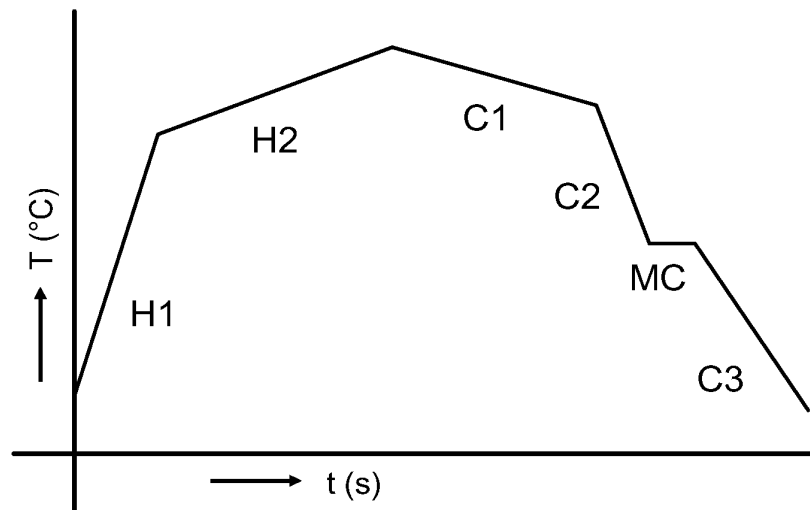


Fig. 2

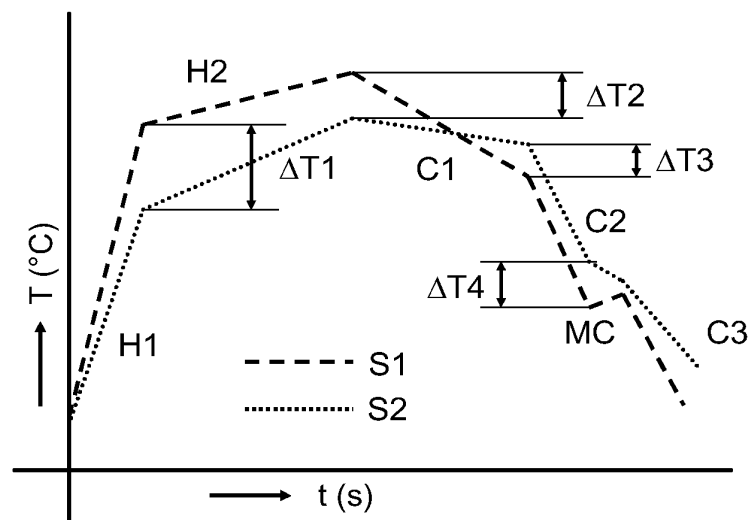


Fig. 3

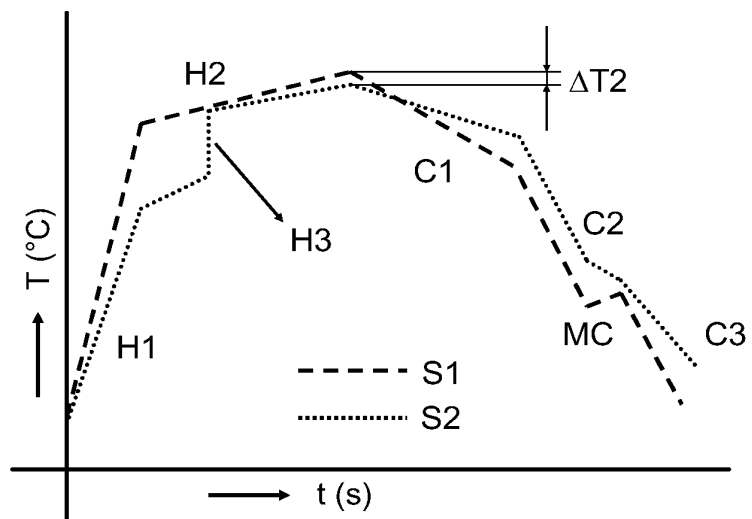
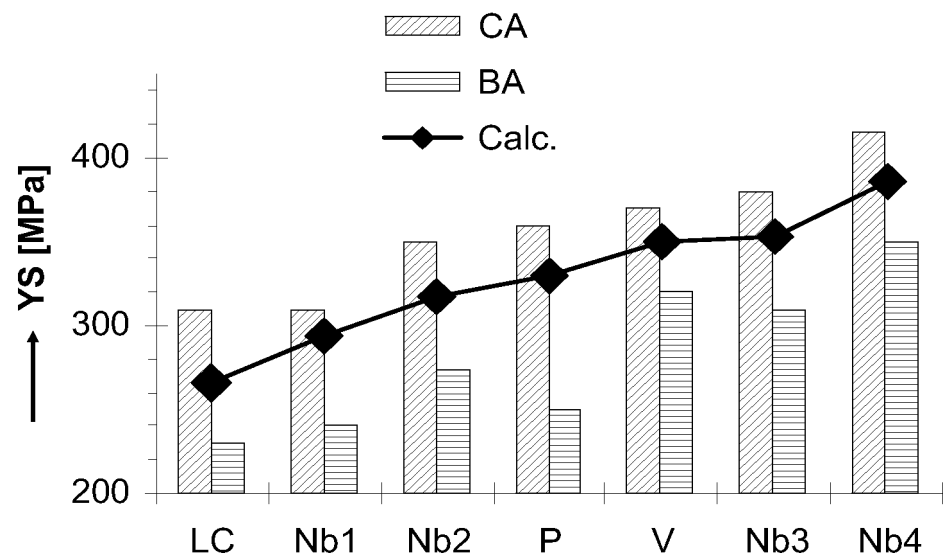


Fig. 4



REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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