AUSTRALIA
PATENTS ACT 1990
PATENT REQUEST : STANDARD PATENT

I/We being the person(s) identified below as the Applicant(s), request the grant of a patent to the person(s) identified below as the Nominated Person(s), for an invention described in the accompanying standard complete specification.

Full application details follow:

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[54] Invention Title:

Process for the continuous production of a rolled stainless steel sheet strip and continuous production line for carrying out the process

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Basic Convention Application(s) Details:

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AUSTRALIA
PATENTS ACT 1990
NOTICE OF ENTITLEMENT

We, Usinor Sacilor, the applicant/Nominated Person named in the accompanying Patent Request state the following:

The Nominated Person is entitled to the grant of the patent because the Nominated Person would, on the grant of a patent for the invention to the inventors, be entitled to have the patent assigned to the Nominated Person.

The Nominated Person is entitled to claim priority from the basic application listed on the patent request because the applicant in respect of the basic application UGINE S.A., has merged with USINOR SACILOR on 12 January, 1996.

DATED this TWENTY FIRST day of OCTOBER 1996

[Signature]

a member of the firm of DAVIES COLLISON CAVE
for and on behalf of the applicant(s)

(DCC ref: 1856874)
1. Process for the continuous production, on a production line, of a rolled stainless steel sheet strip having an improved surface state, characterized in that the hot produced sheet is subjected to a treatment comprising at least,

- a primary pickling for removing scale,
- a cold rolling in at the most three rolling passes,
- a final annealing,
- a final pickling,
- and a cold rolling of the "skin pass" type.
AUSTRALIA
PATENTS ACT 1990
COMPLETE SPECIFICATION

NAME OF APPLICANT(S):

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INVENTION TITLE:

Process for the continuous production of a rolled stainless steel sheet strip and
continuous production line for carrying out the process

The following statement is a full description of this invention, including the best method
of performing it known to me/us:-
The invention relates to a process for continuously producing on a production line a rolled stainless steel sheet strip having an improved surface state.

Various processes are known for producing a stainless steel sheet strip from a hot rolled sheet strip, which processes have for purpose to obtain a sheet having an improved surface state characterized, for example, by a roughness Ra lower than 0.25 micrometre.

A process is known for producing a stainless steel sheet strip comprising operations for annealing the hot rolled sheet strip, and pickling said strip, said operations being carried out on a first production line. On a second line, the pickled sheet strip is subjected to a cold rolling operation on a reversing mill, the rolling operation being effected in five passes, and generally in seven or more passes, with a reduction which may vary between 50 and 80%. Cold rolled in this way, the sheet strip is then put into a coil and conveyed on a line for undergoing an annealing followed by a pickling. Lastly, the pickled sheet strip is subjected to a cold rolling operation of the "skin pass" type which may be followed by a levelling and a shearing operation.

The drawback of this process is due in particular to the large number of plants in which the hot rolled strip of
sheet must be treated in succession with consequently the
costs of the treatment, the maintenance and the personnel,
many intermediate handlings with risks of damage to the
sheet strip, losses of metal due to rejection, and
treatment durations generally longer than a week and even
two weeks or more due to the waiting periods before each of
the plants, which waiting periods require corresponding
stocks, stocking areas and stocking costs.

An object of the invention is to provide a continuous
production of a stainless steel sheet strip having on the
surface given characteristics of roughness and homogeneity
of appearance, the sheet strip being obtained on a single
production line, the production process ensuring a
considerable reduction in the number of passes in the cold
rolling operation and permitting carrying out economically
all of the operations required to obtain a sheet strip
having a predefined surface quality.

The invention therefore provides a process for the
continuous production on a production line of a rolled
stainless steel sheet strip having an improved surface
state which is characterized in that the hot produced sheet
is subjected to a treatment comprising at least:

- a primary pickling for removing scale,
- a cold rolling in at the most three rolling passes,
- a final annealing,
- a final pickling, and
- a cold rolling of the "skin pass" type.
Preferably, the treatment further comprises, before the primary pickling, a stretcher levelling producing a residual elongation of 1 to 5% for cracking the oxide layer and rendering the sheet planar.

Other features of the invention are:

- the sheet strip is further subjected to an abrasion which may be carried out before, and/or after, and/or during the primary pickling operation,
- the abrasion is obtained with at least one brush,
- the sheet strip is, after the stretcher levelling, subjected to a shot blasting for removing scale,
- for a ferritic steel sheet strip, the cold rolling of the strip is carried out with a reduction lower than 60%,
- for an austenitic steel sheet strip, the cold rolling is carried out with a reduction lower than 50%,
- the sheet strip is subjected to a final annealing carried out in an oxidizing atmosphere at a temperature between 800 and 1200°C,
- the sheet strip, after cold rolling and final annealing, is subjected to a cold rolling of the "skin pass" type, the cold rolling producing an elongation of the strip of between 0.5 and 2%,
- the sheet strip is, after the final pickling and the rolling of the "skin pass" type, further subjected to a levelling,
- the sheet strip is further subjected to a shearing operation for trimming the edges.
The invention also relates to a production line for producing a stainless steel sheet strip by the process according to the invention, characterized in that it comprises in succession:

5  a stretcher leveller,
a primary pickling station,
a non-reversing continuous cold rolling device,
a final annealing device,
a final pickling device,
10  a cold rolling device of the "skin pass" type.

Further features of the line are:
the line further comprises a shot blasting station,
the primary pickling station comprises means for ensuring a stoppage on the line of the pickling of the sheet strip,
15  the pickling station comprises a tank containing an acid bath provided with a device for extracting from the bath the sheet strip immersed in the latter,
the pickling station is of the spraying type,
20  the pickling station is electrolytic,
the tank of the electrolytic pickling station contains an electrolyte selected from a neutral salt, a phosphoric acid, or a mixture thereof,
the line further comprises abrasion means which may be placed before and/or after the pickling station and/or in the primary pickling station,
25  the abrasion means is a brush,
the cold rolling device comprises at the most three stands of the multiroll type, the working rolls having a diameter of less than 180 mm and preferably less than 150 mm,
the line further comprises at least one levelling station associated with the cold rolling device of the "skin pass" type,
the line further comprises at least one device for shearing the edge portions of the strip.

The following description and the accompanying drawings, which are given merely by way of non-limitative examples, will explain the invention.

In the drawings:

Fig. 1 shows a diagram representing in a cold rolling operation the evolution of the surface state of a sheet strip as concerns roughness, as a function of the number of passes and of the reduction produced by the cold rolling.

Fig. 2 shows a curve of the rolling forces as a function of the reduction of the cold rolling for two qualities of rolling oil employed.

Fig. 3 shows a block diagram of the rolling line according to the invention.

Fig. 4 shows another block diagram of the rolling line according to the invention.

The invention relates to a process for the continuous production, on a production line, of a rolled stainless steel sheet strip having an improved surface state 2B,
characterized by a roughness Ra lower than 0.25 micrometre, and even lower than 0.15 micrometre in the direction of the length and in the direction of the width, the process producing no change in the apparent colour, no halo and no trace of oxide.

According to the process of the invention, a hot rolled sheet strip is subjected, first of all, to a stretcher levelling. The stretcher levelling has for purpose to cause, by the stretching which produces a residue elongation of 1 to 5 % of the sheet strip, a cracking of the layer of oxide on said strip. The stretcher levelling brings about, at this stage of the process, an improvement in the flatness of the sheet strip which has an influence on the following operations, such as the shot blasting. After the stretcher levelling operation, the sheet strip is subjected to a pickling which ensures an improved surface state of the sheet strip as compared with a conventional method for producing a sheet strip, as described in the prior art referred to hereinbefore.

In Fig. 1, the curves A and B provide a diagram representing, in a cold rolling operation, the evolution of the surface state of a sheet strip as concerns roughness, as a function of the number of passes and the reduction in thickness. The evolution of the surface state in the conventional process is represented by the curve A and that of the invention by the curve B.
As shown on the curves A and B of Fig. 1, the variation in the roughness of a sheet strip decreases as a function, on one hand, of the reduction of the strip in the course of the cold rolling and, on the other hand, of the number of passes in the cold rolling. The number of passes \( P \) is represented on the curves A and B of Fig. 1 by a number within a circle.

The conventional process, in which the sheet strip had been subjected, before the cold rolling, to an annealing followed by a shot blasting and a pickling, permits obtaining a sheet strip having a roughness \( R_t \) of 25 to 40 micrometres and an \( R_a \) of 2.5 to 4 micrometres. In the process according to the invention, the strip has, before cold rolling, a roughness \( R_t \) of 10 to 20 micrometres and an \( R_a \) of 1 to 2 micrometres. The strip is moreover completely devoid of oxide.

Preferably, and for the purpose of perfecting the surface state of the stretcher levelled sheet strip, the sheet strip is subjected to an abrasion, for example an abrasive brushing, the brushing being carried out before, after, or during the primary pickling operation.

Also for perfecting the surface state of the sheet strip before the cold rolling operation and the pickling, the sheet strip may be subjected to a shot blasting operation which facilitates the removal of the scale without however disturbing in an excessive manner the surface of the sheet. Indeed, the hot rolled sheet strip
which has not been annealed has high mechanical characteristics which, when associated with mild shot blasting conditions, permit a shot blasting without harmful disturbance of the surface of the sheet strip.

While it has been acknowledged that the surface state of a sheet strip was in particular improved when the sheet strip is subjected to a large number of passes in the cold rolling operation, the Applicant has discovered that the quality of the surface state of the sheet strip as concerns roughness is due in a large part to the quality of the surface state of the sheet strip before the cold rolling operation. The cold rolling, notwithstanding a large number of passes, removes only very progressively the roughness which appeared in the course of the treatment of the sheet strip before the cold rolling.

According to the invention, the associated stretcher levelling and pickling operations have for purpose to ensure on the surface of the sheet strip a state of roughness which is such that it permits considerably reducing the number of passes in the cold rolling operation. This is shown by the curve B in Fig. 1. According to the invention, the reduction in the number of passes in the cold rolling imposes rolling conditions which ensure a reduction in the roughness of the sheet strip. 

The total reduction in the thickness of the sheet strip is optimized to avoid exceeding a rolling force of 800 tons per metre of width exerted on the rolls of the
rolling mills. Beyond this limit, there is formed a thick and rough transfer layer on the working rolls which print onto the rolled sheet strip and impart thereto a high roughness corresponding to an *Ra* of about 1 micrometre.

The diameter of the rolling mill rolls is less than 180 mm, and preferably less than 150 mm, to permit high reductions in the thickness of the strip with rolling forces lower than 800 tons per metre of width.

Such rolls ensure an improvement in the roughness in the course of the cold rolling. The rolls of the last stand must be polished so as to have very low roughness, preferably lower than 0.1 micrometre.

In order to reach reductions in thickness of the sheet strip of less than 60%, it is preferable to employ paraffinic rolling oils containing one or more friction reducing additives, the additives being preferably one or more esters of which the total concentration in the oil is higher than or equal to 10%. The rolling oils employed permit achieving the aforementioned reductions in a number of passes which is still further reduced, for example two passes, without increasing the rolling forces. For example, the use of a paraffinic oil containing at least 10% ester, permits, for a given rolling force, a reduction in the thickness of the sheet strip of 35% as compared with the reduction of 25% obtained with a conventional oil containing only 1% ester.

Fig. 2 shows two curves A and B corresponding to the
allowed rolling forces as a function of the different rolling reductions for two ester concentrations of a rolling oil.

In order to perfect the surface state of the stretcher levelled hot rolled sheet strip, said strip is subjected to a brushing which may be abrasive, the brushing being carried out before, after or during the chemical pickling operation.

For the same purpose, the stretcher levelled hot rolled sheet strip may be, before pickling and/or brushing, subjected to a shot blasting which facilitates the separation of the scale.

The sheet strip produced by the process according to the invention has a surface quality corresponding to a roughness Ra which is lower than 0.25 micrometre and may reach a roughness Ra lower than 0.15 micrometre.

The invention also relates, as shown in Fig. 3, to a production line 1 for carrying out the process, this production line comprising in association a stretcher leveller 2 and a primary pickling station 3 ensuring a stoppage of the pickling operation on the line simultaneously with the stoppage of the cold rolling device.

Further, a very large reduction in the duration of the pickling treatment of the steel is imposed to avoid an accumulation or gathering of the strip between the various devices of the line. Such a continuous production line has
the advantage of reducing the intermediate handling and the stocking.

In the field of the cold rolling of stainless steel sheet strips, the treatment of the working rolls of the rolling mill must impart to said rolls a sufficient wear resistance to maintain the quality of their surface during the rolling of at least one coiled strip of 30 tons. The rolls employed are of high-speed steel, supercarburized with vanadium or sintered, and must be changed practically for each rolled coil. Consequently, the line must be stopped in a regular manner for each changing of the working rolls. The use of a pickling bath before the cold rolling device presents the problem of the frequent stoppages of the mill and of the control of the durations of the passage of the strip in the pickling bath. Indeed, the different stoppages of the sheet strip on a single production line requires an arrangement ensuring a reserve supply of strip by means of strip accumulators placed between the various stations and devices.

According to the invention, the primary pickling station 3 is followed by a cold rolling device 4. The pickling station 3 comprises a tank containing an acid bath provided with a device for extracting the immersed sheet strip.

 Preferably, and for ensuring the frequent stoppages on the line without deteriorating the strip by an uncontrolled chemical attack, the pickling station 3 is of the spraying
The station pickling by spraying permits an instantaneous stoppage of the pickling by the stoppage of the spraying simultaneously with the stoppage of the mill.

In another embodiment, the primary pickling station 3 may be an electrolytic pickling station comprising a tank for example of neutral salt, the stoppage of the station being achieved by stopping the electric power supply of the electrolytic tank.

The pickling station 3, provided with means for stopping the pickling, permits reducing in volume or eliminating the strip accumulator 13 usually placed between the pickling station 3 and the cold rolling device 4.

The line 1 comprises, following on the non-reversing cold rolling device 4 having at the most three stands 5, a device 6 for annealing the cold rolled strip, a final pickling station 7, and a cold rolling device of the "skin pass" type 8.

The line 1 according to the invention may further comprise, placed after the stretcher levelling device, as shown in Fig. 4, a shot blasting station 9 and/or brushing means 10 which may be abrasive, contributing to the refining of the quality of the surface of the sheet strip before cold rolling so as to obtain an improved surface state of the sheet strip after said cold rolling, the number of passes of which is reduced.

The production line may further comprise, following on the cold rolling device of the "skin pass" type, a
stretcher leveller device 11 associated with a shearing device 12. A second shearing device may be placed after the stretcher leveller 2.

In one embodiment, a hot rolled austenitic steel sheet strip having a thickness of 2 mm is subjected to a stretcher levelling which produces a residual elongation of 3.5 %.

The sheet strip is then pickled in two baths of sulphuric acid. At this stage of the process, the sheet strip has a roughness of lower than 1.5 micrometre.

The sheet strip is then subjected to a cold rolling in three passes on a Sendzimir cold rolling train of type ZHi. The sheet strip is cold rolled with a reduction of 50 %. The sheet strip is annealed and then pickled. It then has, after these short cold rolling, annealing and pickling operations, a roughness Ra lower than 0.25 micrometre. The sheet strip is subjected, in one pass, to a cold rolling of the "skin pass" type producing an elongation of 0.8 %. The sheet strip then has a roughness Ra lower than 0.1 micrometre.

In another embodiment, a hot rolled ferritic steel sheet strip stabilized with titanium and having a thickness of 3 mm is subjected to a stretcher levelling producing a residual elongation of 4 %.

The sheet strip is then pickled in an H₂SO₄ acid bath, then in an HNO₃ acid bath. At this stage of the process the sheet strip has a roughness Ra lower than 2 micrometres.
The sheet strip is then subjected to a cold rolling in two passes with a reduction of 50% on Sendzimir mills of type 2Hi, annealed and pickled. It has, after the short cold rolling, annealing and pickling operations, a roughness Ra lower than 0.25 micrometre. The sheet strip is then subjected to a cold rolling operation in one pass of the "skin pass" type producing an elongation of the strip of 0.8%. The sheet strip then has a roughness lower than 0.15 micrometre.

On this production line, there is the problem of the pickling and in particular of a pickling within an imposed short period of time, in order to avoid imperatively an accumulation of the treated strip between the various devices arranged in succession on the continuous strip producing line.

In another embodiment, the stainless steel sheet strip is pickled by an aqueous pickling solution containing hydrochloric acid and ferric and ferrous pickling ions in solution, for a purpose of maintaining a constant pickling power of the aqueous solution of hydrochloric acid and maintaining the concentration of Fe³⁺ ions, by reoxidation of the Fe²⁺ ions generated in the course of the pickling, the REDOX potential being maintained at a value between 0 and 800 mV, this potential being measured between a platinum electrode and a reference Ag/AgCl electrode placed in the solution.

The pickling operations before rolling in a continuous
line ensure an optimum quality of the surface state of the strip. The effectiveness of the pickling may permit, depending on the quality of the sheet strip, the elimination of the mechanical treatments of the stretcher levelling type, shot blasting, brushing, thereby considerably reducing the steel sheet strip production line.

According to the process of the invention, the reduction in the number of passes in the cold rolling permits providing a continuous line having a reduced cold rolling device, thereby reducing the investment cost for obtaining a sheet of quality and also greatly reducing the line maintenance and personnel costs. The continuous line thus results in a very considerable reduction in the duration of the treatment, and therefore in the stocks of semi-finished products, and the elimination of intermediate handlings which are the cause of defects and loss of metal.
THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. Process for the continuous production, on a production line, of a rolled stainless steel sheet strip having an improved surface state, characterized in that the hot produced sheet is subjected to a treatment comprising at least,
   a primary pickling for removing scale,
   a cold rolling in at the most three rolling passes,
   a final annealing,
   a final pickling,
   and a cold rolling of the "skin pass" type.

2. Process according to claim 1 further comprising, before the primary pickling of the strip, a stretcher levelling producing a residual elongation of 1 to 5 % for cracking the layer of oxide and rendering the sheet planar.

3. Process according to claim 1 or 2, wherein the sheet strip is further subjected to an abrasion which may be effected before, and/or after, and/or during the primary pickling operation.

4. Process according to claim 3, wherein the abrasion is effected by at least one brush.

5. Process according to any one of the claims 2 to 4, wherein the sheet strip is, after the stretcher levelling, subjected to a shot blasting for removing scale.

6. Process according to any one of the claims 1 to 5, wherein, for a ferritic steel sheet strip, the cold rolling of the strip is carried out with a reduction lower than or
7. Process according to any one of the claims 1 to 5, wherein, for an austenitic steel sheet strip, the cold rolling of the strip is effected with a reduction lower than or equal to 50%.

8. Process according to any one of the claims 1 to 7, wherein the sheet strip is subjected to a final annealing effected in an oxidizing atmosphere at a temperature between 800 and 1200°C.

9. Process according to any one of the claims 1 to 8, wherein the sheet strip is, after the cold rolling and final annealing, subjected to a cold rolling of the subjected type, the cold rolling producing an elongation of the strip of between 0.5 and 2%.

10. Process according to any one of the claims 1 to 9, wherein the sheet strip is, after final pickling and rolling of the "skin pass" type, further subjected to a stretcher levelling.

11. Process according to any one of the claims 1 to 10, wherein the sheet strip is further subjected to a shearing operation for cutting the edge portions.

12. Production line for producing a stainless steel sheet strip for carrying out the process according to any one of the claims 1 to 11, comprising in succession:

   a stretcher leveller,
   a primary pickling station,
   a non-reversing device for continuously cold rolling,
a final annealing device,
a final pickling device,
a device for cold rolling of the "skin pass" type.

13. Line according to claim 12, further comprising a shot blasting station.

14. Line according to claim 12 or 13, wherein the primary pickling station comprises means for stopping on the line the pickling of the sheet strip.

15. Line according to any one of the claims 12 to 14, wherein the pickling station comprises a tank containing an acid bath provided with a device for extracting from the bath the sheet strip immersed in the bath.

16. Line according to any one of the claims 12 to 14, wherein the pickling station is of the spraying type.

17. Line according to any one of the claims 12 to 14, wherein the pickling station is electrolytic.

18. Line according to claim 17, wherein the tank of the electrolytic pickling station contains an electrolyte selected from a neutral salt, phosphoric acid or a mixture thereof.

19. Line according to any one of the claims 12 to 18, wherein the line further comprises abrasion means which may be placed before, and/or after the pickling station, and/or in the primary pickling station.

20. Line according to claim 19, wherein the abrasion means is a brush.

21. Line according to any one of the claims 12 to 20,
wherein the cold rolling device comprises at the most three stands of the multiroll type having working rolls of a diameter less than 180 mm and preferably less than 150 mm.

22. Line according to any one of the claims 12 to 21, wherein the line further comprises at least one stretcher levelling station associated with the cold rolling device of the "skin pass" type.

23. Line according to any one of the claims 12 to 22, further comprising at least one device for shearing edge portions of the strip.
24. A process according to claim 1 substantially as hereinbefore described with reference to the drawings and/or Examples.

25. The steps, features, compositions and compounds disclosed herein or referred to or indicated in the specification and/or claims of this application, individually or collectively, and any and all combinations of any two or more of said steps or features.

DATED this TWENTY FIRST day of OCTOBER 1996

Usinor Sacilor

by DAVIES COLLISON CAVE
Patent Attorneys for the applicant(s)
ABSTRACT

Process for continuously producing on a production line a rolled stainless steel sheet strip having an improved surface state, characterized in that the hot produced sheet is subjected to a treatment comprising at least:

- a primary pickling for removing scale,
- cold rolling in at the most three rolling passes,
- a final annealing,
- a final pickling, and
- a cold rolling of the "skin pass" type.

There is optionally effected, before the primary pickling, a stretcher levelling which produces a residual elongation of 1 to 5 % for cracking the layer of oxide and rendering the sheet planar.

Figure 1.
FIG. 1

Process of invention

Conventional process

Rt (μm)

% Reduction

0 10 20 30 40 50 60 70 80

0 5 10 15 20 25 30

1 2 3 4 5 6 7 8 9 10 11
FIG. 2

Rolling force

\( t/m \)

800

Oil with 1% ester

Oil with 10% ester

25 35

% Reduction