

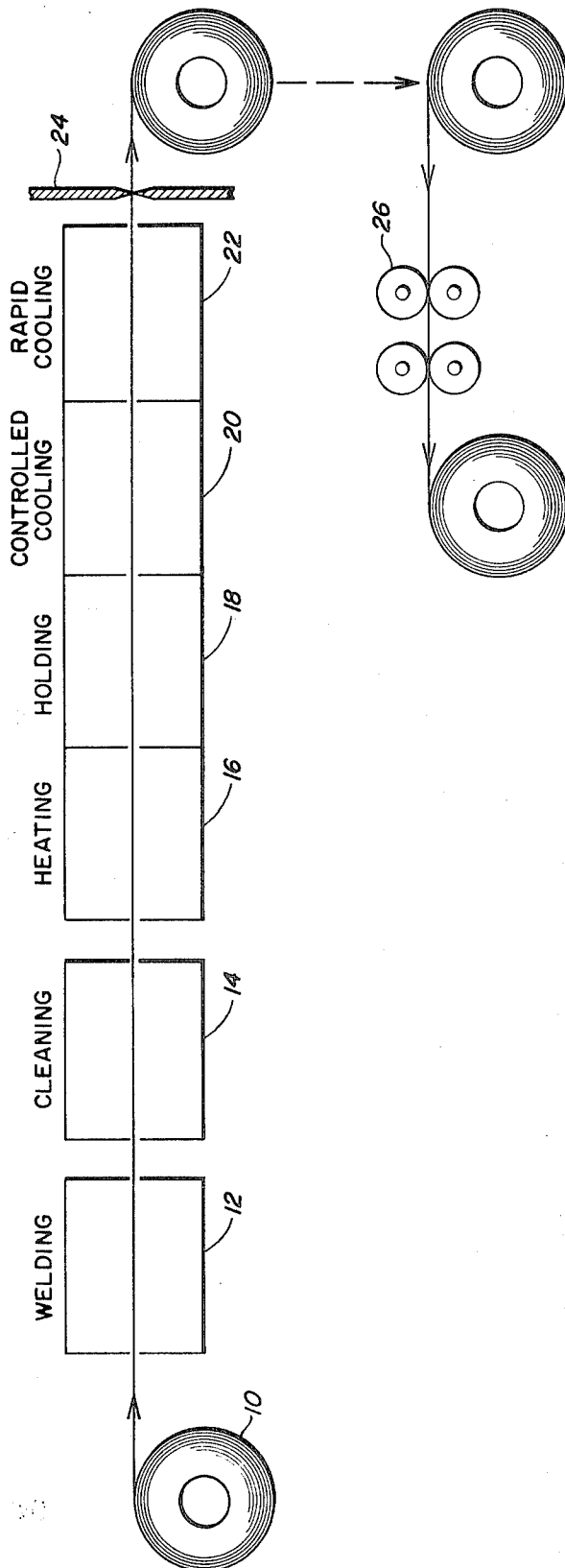
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ATMOSPHERE CONTROLLED ANNEALING PROCESS

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ATMOSPHERE CONTROLLED ANNEALING PROCESS

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4 Claims

ABSTRACT OF THE DISCLOSURE

A method of controlling the surface appearance of continuous annealed and temper rolled steel strip suitable for use in the manufacture of metallic coated steel strip, such as tin plate. The bright and uniform appearance of the strip is achieved by providing a protective atmosphere containing a maximum of about 1.5% hydrogen during the controlled cooling down to about 1000° F., and a maximum of about 0.5% hydrogen during the rapid cooling down to below about 250° F.

BACKGROUND OF THE INVENTION

This invention is directed to a process for controlling the surface appearance of a cold-reduced steel strip which is subjected to a process anneal followed by a skinpass or temper rolling. While the process anneal has long been established as a practice in the steel industry, insufficient attention has been given to the imposition of controls on the annealing atmosphere. The present invention treats that aspect of said process, and as a result has found a means for achieving a bright and uniform surface appearance without affecting the roll surfaces of the temper mills.

In the production of cold-reduced carbon steels, the hardness of the strip after a first cold reduction is such as to require a softening treatment. The two conventional treatments are known as a box anneal, where the strip is heated in a controlled atmosphere in coil form, and a process anneal. In the latter, a plurality of coils welded end to end are treated continuously in an elongated furnace.

In order to attain high production from the latter process, the strip moves at speeds of up to about 2000 ft./min. through the furnace. To metallurgically affect the steel, it must be rapidly heated, recrystallized, and cooled in a relatively short period of time. The prior art, as exemplified by U.S. Pat. No. 3,099,592 to Garber, is directed to a method of cutting the time needed to effect the anneal so as to take advantage of smaller and less costly furnaces. While such a system represents an advance over existing systems, it did not recognize the significance of controlling the annealing atmospheres, nor the advantages to be gained therefrom.

SUMMARY OF THE INVENTION

This invention is directed to a continuous process of annealing a ferrous strip, followed by temper rolling thereof, which strip is suitable for use as a subsequently metallic coated or uncoated strip, to reveal a bright uniform surface appearance. More particularly, said invention covers a preferred sequential operation as follows:

- Heating cleaned ferrous strip to temperature between about 1100° to 1200° F.,
- Holding at said temperature for sufficient time to effect complete recrystallization,
- Cooling in a controlled atmosphere containing a maximum of 1.5% hydrogen to a temperature between about 700° to 1000° F.,
- Rapidly cooling in an atmosphere containing a maximum of about 0.5% hydrogen to a temperature below about 250° F., and

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- Temper rolling to effect a reduction of said strip by an amount up to about 2.0%.

BRIEF DESCRIPTION OF DRAWING

- The figure is a schematic representation of a continuous anneal line and temper mill for treating a ferrous strip in accordance with the present invention.

DESCRIPTION OF PREFERRED EMBODIMENT

- In the practice of this invention, an improved process anneal is imposed on a cold reduced ferrous strip resulting in a bright uniform surface appearance following the temper rolling thereof. Such a process results in considerable cost savings as a result of less frequent temper mill roll changes and greater mill yields. The advantages will become more apparent hereinafter.

- By way of background, and in preparation for treatment by the invention herein, a ferrous alloy having a chemistry within the following maximum limits, by weight:

	Percent
Carbon	0.13
Manganese	0.60
Phosphorus	0.015
Sulfur	0.05
Silicon	0.010
Copper	0.06
Nickel	0.04
Chromium	0.06
Molybdenum	0.05
Other residuals	0.02
Iron	Balance

- is melted and then cast, either by a continuous practice into cut slabs, or cast into ingots and rolled to slabs. While the above chemistry represents typical limits for capped and rimmed steels, it may be modified to yield a killed or semi-killed steel. Thus, the process is broadly applicable to all said steels.

- In any case, where insufficient heat remains in the slabs, they are reheated to a temperature above about 2000° F. and converted to a flat rolled strip and coiled in a conventional manner by hot rolling to thicknesses ranging between about 0.075 to .180 inches, depending on the final application therefor. To achieve a cold reduced product therefrom, the hot rolled strip is cleaned, such as by pickling, and cold rolled in one or more stages by an amount up to about 90%. At this stage the thickness of the strip ranges between about .0077 to .015 inches.

- In order to facilitate cold reducing of the strip and to protect the surface against oxidation, a thin coating of oil is applied thereto. For the processing subsequent to the oil coating, reference may be made to the Figure.

- The hard, cold rolled ferrous strip is fed from a decoiler 10 to a strip welder 12 where successive coils, welded end to strip end, exit therefrom to effect the continuous operation. Prior to entering the annealing cycle, the strip surface is subjected to a cleaning operation 14 where the oil is removed. From here the strip enters a conventional furnace heating section 16 which raises the temperature of the strip to between about 1100° to 1200° F. For a line speed of about 2000 ft./min., this raise in temperature would take about 20 seconds. The temperature of the strip is maintained for an additional period of time, typically about 20 seconds at the speed above, in a conventional holding section 18 to effect complete recrystallization of said strip. While it is important that the atmosphere in sections 16 and 18 be reducing to preclude the formation of oxides on the strip surface, it is the controls imposed in the subsequent sections, particularly the rapid cooling section, which result in the improvements noted previously.

The strip is cooled in two stages, namely, a controlled cooling 20 and a final rapid cooling 22. The first stage cools the strip to a temperature between about 700° to 1000° F., which typically takes about 20 seconds. The final cooling or quenching is to room temperature with an approximate elapsed time of 20 seconds. While high hydrogen contents, such as up to 7%, may be tolerated in the heating and holding sections 16 and 18, the atmosphere within the cooling section 20 must contain no more than about 1.5%, preferably a maximum of about 1.0% hydrogen. As for the cooling section 22, the hydrogen must be kept to a maximum of about 0.5%. Thus, the annealing atmosphere used herein is essentially a hydrogen free reducing gas composed of nitrogen, inert, or non-oxidizing and non-carburizing gases. Following said atmosphere controlled anneal, the strip is sheared 24 into coil lengths and finally subjected to a temper rolling 26 or skin pass to reduce the cross section by an amount less than about 2.0%.

In order to demonstrate the effectiveness of this procedure on a ferrous strip, a capped steel having the following chemistry, by weight:

	Percent
Carbon -----	.09
Manganese -----	.35
Phosphorus -----	.005
Sulfur -----	.020
Copper -----	.02
Silicon -----	.005
Nickel -----	.04
Chromium -----	.03
Molybdenum -----	.009
Tin -----	.003
Iron -----	Balance

was subjected to the processing sequence below—

- (a) Hot reduced to .080 inches.
- (b) Cold reduced to .0084 inches.
- (c) Annealed, at a line speed of about 2000 ft./min.
 - (1) heated to 1150° F. in 20 seconds in atmosphere of 2.8% H₂, balance N₂,
 - (2) held for 20 seconds in atmosphere of 3.0% hydrogen, balance N₂,
 - (3) cooled to about 1000° F. in 20 seconds in atmosphere of 1.1% hydrogen, balance N₂ with a dew point of -34° F.,
 - (4) cooled to temperature below 250° F. in 20 seconds in atmosphere of .5% hydrogen, balance N₂ with a dewpoint of -30° F., and
- (d) Temper rolled ½ %.

The resulting strip exhibited a uniformly bright surface.

In similarly processed ferrous strip, where the hydrogen content of the atmosphere exceeded about 3.0% during the heating, holding and cooling thereof, the temper rolled strip revealed a dull appearance. Without desiring to be bound by the theory proposed, it is believed

that the air leaking into the furnace reacted directly with the strip surface to form oxides, rather than with the hydrogen. The surface oxides thus formed were immediately reduced by the hydrogen to form a surface of "reduced" or "sponge" iron. When the subsequent temper rolling operation was performed on the as-annealed strip, the "sponge" iron surface quickly wore the blast on the entry stand work rolls. The strip then caused the finishing stand work rolls to dull, which in turn produced a dull strip surface. As a consequence, irrespective of the theory surrounding the problem, unsuitable strip resulted causing frequent changes to be made in the temper mill rolls.

I claim:

1. In a continuous process of annealing followed by temper rolling to produce a steel strip having a bright surface appearance, the improvement comprising in combination therewith the steps of rapidly heating said strip to a temperature between about 1100° to 1200° F., holding at said temperature for a time sufficient to effect complete recrystallization, cooling said strip to a temperature between about 700° to 1000° F. in a protective atmosphere containing a maximum of about 1.5% hydrogen, rapidly cooling the strip to a temperature below about 250° F. in a protective atmosphere containing a maximum of about 0.5% hydrogen, and temper rolling to effect a reduction in the thickness of said strip by an amount less than about 2.0%.

2. The process according to claim 1 wherein the atmosphere bathing the strip during the heating and holding steps contains a maximum of about 7.0% hydrogen.

3. The process according to claim 1 wherein the maximum hydrogen content in the atmosphere of the initial cooling step is 1.0%.

4. The process according to claim 1 wherein the balance of the atmosphere during the cooling steps is nitrogen.

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WAYLAND W. STALLARD, Primary Examiner

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