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EP-A- 0 078 446
JP-A-60 135 530

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Description

This invention relates to a preheating method in the continuous heat-treatment of steel strip for progressively heating the steel strip in a plurality of stages to temperatures as near to those in the heating zone as possible.

A steel strip continuous heat-treating installation, for example, a steel strip continuous annealing installation, usually comprises heating, soaking and cooling zones. A steel strip is heated to 650°C-850°C in the heating zone. As it is necessary to maintain a reducing atmosphere in the heating zone, radiant tube heating has been employed which, however, makes the installation of the heating zone complicated and large-sized. It is therefore important to preheat the steel strip on the entry side of the heating zone in order to make the installation compact and improve the production efficiency.

Concerning the preheating on the entry side of the heating zone, Japanese Laid-open Patent Applications Nos.57-41,330 and 58-73,727 disclose a method of preheating a steel strip in which sensible heat of burned waste heat from a heating zone is recovered in a heating medium by means of a heat-exchanger and the heating medium is introduced into passages formed in rolls about which the steel strip is wound.

In this disclosed method, the sensible heat of the burned waste heat at 300-350°C is recovered in the heating medium until the temperature becomes approximately 150°C in order to avoid a problem of dew point of oxygen, and thereafter the steel strip is preheated. In this manner, it is possible to preheat the steel strip to approximately 130-140°C to improve the recovery of waste heat.

In this case, however, the steel strip preheated to approximately 130-140°C is rapidly heated to 600-850°C by radiation heating mainly by radiant tubes. As such a heating has a limitation of heating speed, a huge installation is needed in order to increase the production. Moreover, as the preheating temperature is relatively low, it would be desirable to improve the thermal efficiency.

On the other hand, Japanese Laid-open Patent Application No.57-76,133 discloses a heating method using rolls heated by induction heating coils without using the burned waste gas. This publication discloses an example of heating steel strips to 800°C using heated rolls at 1,000°C. Because of the great temperature difference between the steel strip and the rolls when the steel strip is wound about the rolls, there is a risk of serpentine movement of the steel strip caused by concave thermal crowns on the rolls due to temperature fall at outer peripheries of the rolls about which the steel strip is wound.

Even if the rolls are inherently provided with convex crowns in profile in order to stabilize the crown of the heating rolls, it is very difficult to maintain stable crowns because of variation in temperature of the steel strip passing about the rolls according to thickness of the steel strip in case of large temperature difference between the steel strip and heating rolls.

Moreover, it has been known that there is provided on the entry side of a heating zone a preheating furnace into which burned waste gas is directly introduced or there is provided on the entry side of a heating zone a non-oxidizing furnace for preheating steel strips (direct firing system). With the former, however, the burned waste gas directly contacts steel strips, so that there is a tendency for surfaces of strips to become worse due to oxidization of the surfaces and foreign substances (oxides, carbides and the like) in the waste gas attached on the surfaces. In the latter, the initial cost is increased.

Furthermore, Japanese Laid-open Patent Application No.60,135,530 discloses a preheating method in which sensible heat of burned waste gas from a radiant-tube equipped heating furnace is recovered by using it to heat an atmospheric gas stream in a heat exchanger and the resulting heated gas stream is blown on to steel strip to preheat it. In this method, however, the preheating temperature of the steel strip is at the most 100-200°C. It is impossible to obtain higher preheating temperature. When the temperature of preheated steel strips is within 100-200°C, bad configuration of the rolled steel strips is not straightened by such a low temperature preheating and is maintained even when the steel strips are in an upstream half of a heating zone. In that case unevenness of the rolled steel strip is of the order of 1%, therefore, serpentine movements of the steel strips occur while being heated, so that the feeding speed of the steel strips cannot be increased resulting in lower production efficiency. The word "unevenness" is intended to mean a deviation of a steel strip from a complete flatness per a unit length.

It is an object of the present invention to provide a method of preheating steel strip, which makes it possible to achieve high temperature preheating by progressive preheating without causing serpentine movement of the steel strip, so that the heating zone can be made compact and the production efficiency improved.

Thus in accordance with one aspect of the invention, there is provided a method of continuously annealing steel strip in which the strip is preheated and then heated indirectly in a heating zone by means of radiant tubes heated by burned waste gas, characterised in that the preheating is effected progressively in two stages, in the first of which the strip is heated to not more than a maximum predetermined first temperature by direct contact with a gaseous stream which has been heated in a heat exchanger by means of the burned waste gas from the heating zone, and in the second of which the preheated strip from the first preheating stage is further heated to a desired second temperature higher than said maximum first temperature by winding the steel strip over heated rolls through which is circulated a fluid heat medium which has been heated in a heating device to a desired temperature sufficient to cause the strip in the second preheating stage to be raised to said desired higher temperature before entering the heating zone, whereby serpentine movement of the steel strip is substantially reduced.

In accordance with another aspect of the invention, there is provided the use of a progressive preheating of steel strip in two stages for the purpose of minimising serpentine movement of the steel strip in the continuous annealing of steel strip by indirect heating with radiant tubes in a heating zone, the first preheating being effected by direct heating with a gaseous atmosphere containing sensible heat recovered by heat exchange with burned waste gas from the heating zone, and the second preheating being effected by heated rolls through which a fluid heat medium which has been heated to a desired temperature in a heating device is circulated so as to preheat the steel strip to a higher temperature than that reached in the first preheating stage.

In a preferred embodiment, in the case of using an oxygen-containing gas such as air in the first stage preheating, the temperature of the steel strip is maintained lower than a predetermined temperature, such as by controlling amounts of the gas directed onto the steel strip, in order to prevent formation of thick oxide films on the steel strip. The second stage preheating is preferably effected in a non-oxidizing atmosphere.

In the second preheating stage, a heat medium is heated in a heat medium heating device and supplied and circulated into the rolls, thereby heating the rolls to a desired temperature. The temperature of the steel strip is preferably maintained lower than a predetermined temperature by controlling at least one factor among flow rate and temperature of the heat medium and winding angles of the steel strip about the rolls.

For a better understanding of the invention and to show how the same may be carried into effect, reference will now be made, by way of example, to the accompanying drawings in which:

Fig. 1 is a schematic view illustrating a heating apparatus for effecting the method according to the invention;

Fig. 2 is a graph illustrating a comparison between the thermal efficiency of the invention and conventional methods;

Fig. 3 is a graph illustrating a comparison between fall in production efficiency of the invention and conventional methods;

Fig. 4 is a graph illustrating the relation between the fall in production efficiency due to serpentine movement of the invention compared with conventional methods;

Fig. 5 is a graph illustrating serpentine movement in connection with temperature difference between heat medium and steel strip;

Fig. 6 is a graph illustrating the relation between thickness of oxide films and steel strip temperature;

Fig. 7 is a graph illustrating the relation between surface conditions and steel strip temperature;

Fig. 8 is a graph illustrating the relation between surface conditions and atmosphere in preheating zones; and

Fig. 9 is a graph illustrating the relation between steel strip temperature and investment and repayment indexes.

Referring to Fig. 1, in accordance with the invention, a steel strip 1 is preheated to 100-200 °C in a first preheating zone 2 at a first preheating stage and to 250-500 °C in a second preheating zone 3 at a second preheating stage.

First, burned waste gas is collected from a heating zone 4 including radiant tubes 5 into waste gas collecting ducts 6 and is introduced into a heat-exchanger 7 wherein sensible heat of the waste gas is given to a gas such as the air while the waste gas whose temperature has been lowered is exhausted through a chimney 9 with the aid of a waste gas suction fan 8. The temperature of the waste gas is usually of the order of 400 °C which is lower than those at which the fan and chimney can thermally resist.

The heated gas heated in the heat-exchanging (which is referred to hereinafter "hot blast") is circulated by a hot blast circulating fan 10 to be supplied into hot blast chambers 11 arranged in the first preheating zone 2, so that the hot blast is directed onto the steel strip to heat it to 100-200 °C.

Other than the air, nitrogen, nitrogen mixed with hydrogen somewhat, or the like is suitable as the gas directed onto the steel strip in the first preheating zone 2.

On the other hand, a heat medium 12 in a reservoir 17 is heated in a heat medium heating device 13 and supplied and circulated into rolls 15 with the aid of a circulating pump 14. The heated medium 12 flows through the rolls 15 which are heated by the medium, so that the steel strip 1 from the first preheating zone

2 is wound about the rolls so as to pass through the second preheating zone 3 to heat the steel strip 1 to 250-500 ° C The heat medium 12 which has heated the rolls is returned through a return line 16 into the reservoir 17.

The heat medium may be thermo-oil, metallic sodium, or a molten salt such as a nitrate, for example sodium nitrate or potassium nitrate, or a chloride, for example calcium chloride or sodium chloride. A molten nitrate salt is preferable for preventing corrosion of the rolls.

A thermometer or thermometers 18 for the steel strip are provided on an exit side of the first preheating zone 2 to monitor whether the steel strip 1 is heated at temperatures between 100 and 200 ° C in the first preheating zone. If the temperature of the steel strip is higher than 250 ° C, thick oxide films are produced on surfaces of the steel strip to lower the quality of the surfaces. The amount of the hot blast directed onto the steel strip is controlled by adjusting numbers of revolution of the hot blast circulating fan 10 or provision of dampers in the lines in order to maintain the temperature of the preheated steel strip lower than 250 ° C.

Moreover, a thermometer or thermometers 19 for the steel strip are provided on an exit side of the second preheating zone 3 to monitor whether the temperature of the steel strip on the exit side of the second preheating zone 3 is maintained within 250-500 ° C while one or more of the flow rate and temperature of the heat medium 12 flowing into the rolls 15 and winding angles of the steel strip about the rolls are controlled.

Figs. 2-8 illustrate results of investigation of thermal efficiency, serpentine movement of steel strips, surface conditions and installation investment concerning the invention.

Experiments were carried out under the following conditions.

Steel strips : general cold rolled steel strips
Thickness of steel strips : 0.5-1.6 mm
Width of steel strips : 700-1,600 mm
Speed of steel strips passing through preheating zones : 100-300 m/min
Unevenness of steel strips on entry side of preheating zones : 0.5-1.5%
Tensile force in steel strips : 0.5-1.5 kg/mm^2

Rolls:
- Material : stainless steel
- Outer diameter : 500 mm, 1,000 mm, 1,500 mm
- Number of rolls : 1-5

Steel strip temperature at entry side of the first preheating zone (heating by hot blast) : 40-60 ° C
Steel strip temperature at exit side of the first preheating zone : 100-200 ° C
Steel strip temperature at exit side of the second preheating zone (heating with rolls) : 250-500 ° C
Heat medium : chloride
Temperature of heat medium : 200-600 ° C

Fig. 2 and 3 illustrate thermal efficiencies in cases of the present invention, reference example A using only radiant tubes and reference example B using hot blast and radiant tubes.

As can be seen from Fig. 2, the thermal efficiency is greatly improved by effecting the second stage preheating with rolls mainly by the heat transmission between directly contacting metals.

Fig. 3 is a graph illustrating the fall in production efficiency due to serpentine movements of steel strips occurring before the heating zone when unevennesses of the steel strips are 0.5-1.0% before the heat treatment. This graph clearly shows the superiority of the present invention.

Fig. 4 illustrates the fall in production efficiency due to serpentine movements of steel strips similar to those in Fig. 3, in comparison with the reference example B. It is clear that the serpentine movements can be prevented by rapidly raising the temperature of the steel strips to the order of 500 ° C by preheating with rolls.

In Fig. 5, an abscissa indicates temperature difference between the heat medium and steel strips on the exit side of the second preheating zone and an ordinate indicates serpentine movement of steel strips per one heating roll. When the temperature difference is more than 300 ° C, the serpentine movements increase to an extent that the practical use is prohibitive. It is understood from this fact that the progressive heating with less temperature difference is suitable.

The reason why the large temperature difference increases the serpentine movements of the steel strips is as follows. When the temperature difference is large, center portions of the heating rolls are cooled more than edge portions of the rolls to increase concave crowns occurring on the heating rolls, so that the steel strips become unstable at the center portions of the rolls and tend to move to the edge portions owing to the usual tendency of the steel strips to move toward locations where tensile forces in the steel strips increase.

Fig. 6 illustrates the relation between thickness of oxide films and the temperature of steel strips on the exit side of the first preheating zone heating with hot blast. It is clearly evident that when the temperature of the steel strips is more than 250°C, the thickness of the oxide films increases. Even if the steel strips were reduced after preheating, the bad surface conditions of the steel strips could not be amended as shown in Fig. 7.

Fig. 7 illustrates observation of surfaces of steel strips which were subjected to the treatment for forming phosphate or chromium oxide films thereon after the continuous heat treatment and degreasing. An ordinate indicates the surface conditions of the strips.

Fig. 8 illustrates the surface condition of steel strips in case of the second preheating zone with the air or non-oxidizing atmosphere.

When the steel strips in the second preheating zone with the air were heated to 250-500°C, the oxide films became extremely thick. Even after reducing the steel strips in the heating zone, uneven oxide films remained on the surfaces under the bad surface treated condition.

As seen from Fig. 9, when the temperature of the steel strips on the exit side of the first preheating zone were higher than 200°C, both investment index and repayment year index became higher. In other words, installations such as hot blast circulating fans, motors, heat-exchangers and the like are enlarged to increase both the investment and repayment year.

Moreover, the quantity of heat and flow rate of the respective gases when the temperature of the steel strips on the exit side of the heating zone became 750°C are as follows under the same conditions as those above described.

Burned gas in radiant tubes in the heating zone	:	15×10^6 Kcal/h
		6,500 Nm^3/h
Heat-up gas from a burning furnace for heating a heat medium	:	4×10^6 Kcal/h
		22,000 Nm^3/h

Sensible heat of the heat-up gas was given through a heat-exchanger to the air to be used in the first preheating zone, so that the temperature of the heat-up gas dropped from 600°C to 350°C.

On the other hand, the amount of the air circulating through the first preheating zone was 80,000 Nm/h. The quantity of heat of 2×10^6 Kcal/h was obtained by heat-exchanging. In this case, the air temperature was 250°C on an entry side of the heat-exchanger and 330°C on an exit side thereof.

Example

Steel strips were heated by means of the heating apparatus shown in Fig. 1 under the following conditions.

(I) The first preheating zone

Thickness of steel strips	: 0.6-1.0 mm
Width of steel strips	: 900-1,200 mm
Speed of steel strips passing through preheating zone	: 200-300 m/min
Heating length in the first preheating zone	: 50 m
Amount of circulating hot blast	: 80,000 Nm^3/h (at 200°C)
Pressure of directed hot blast	: 50-70 mm H_2O
Directed hot blast temperature	: 250-350°C
Heat transfer coefficient	: 60 $Kcal/m^2h\cdot°C$

Table 1 shows the temperatures of steel strips on the exit side of the first preheating zone.

Table 1

Steel strip	Thickness (mm)	0.6	0.7	0.8	0.9	1.0
	Width (mm)	900	1,000	1,200	1,000	1,200
Passing speed of steel strip (m/min)		300	280	250	300	200
Temperature of steel strip (°C)		160	150	170	100	200

(II) The second preheating zone

Heat medium	: nitrate
Temperature of heat medium	: 500°C
Heat transmission coefficient between steel strips and heat medium	: 1,000-1,500 $Kcal/m^2h\cdot°C$
Number of rolls	: 4
Diameter of rolls	: 1500 mm
Winding angle of strips about rolls	: 120°

Under above conditions, when steel strips of 0.8 mm thickness were heated at passing speed of 200 m/min, the steel strips at 200 °C on the entry side were heated to 350 °C on the exit side.

This invention allows steel strips to be preheated to higher temperatures for the purpose of preventing serpentine movements of the steel strips, thereby improving the production efficiency and compacting the installation.

Claims

1. A method of continuously annealing steel strip in which the strip is preheated and then heated indirectly in a heating zone by means of radiant tubes heated by burned waste gas, characterised in that the preheating is effected progressively in two stages, in the first of which the strip is heated to not more than a maximum predetermined first temperature by direct contact with a gaseous stream which has been heated in a heat exchanger by means of the burned waste gas from the heating zone, and in the second of which the preheated strip from the first preheating stage is further heated to a desired second temperature higher than said maximum first temperature by winding the steel strip over heated rolls through which is circulated a fluid heat medium which has been heated in a heating device to a desired temperature sufficient to cause the strip in the second preheating stage to be raised to said desired higher temperature before entering the heating zone, whereby serpentine movement of the steel strip is substantially reduced.

2. A method according to Claim 1, wherein the gaseous stream used in the first preheating stage is an oxygen-containing stream and the maximum predetermined first temperature is controlled so as to prevent formation of a thick oxide film on the steel strip.

3. A method according to Claim 1 or 2, wherein the second preheating stage is effected in a non-oxidizing atmosphere.

4. A method according to Claim 1, 2 or 3, wherein said maximum predetermined first temperature is 250 °C and said desired higher second temperature is in the range from 250 to 500 °C.

5. A method according to Claim 1, 2, 3 or 4, wherein the fluid heat medium used in the second preheating stage is a molten nitrate.

6. Use of a progressive preheating of steel strip in two stages for the purpose of minimising serpentine movement of the steel strip in the continuous annealing of steel strip by indirect heating with radiant tubes in a heating zone, the first preheating being effected by direct heating with a gaseous atmosphere containing sensible heat recovered by heat exchange with burned waste gas from the heating zone, and the second preheating being effected by heated rolls through which a fluid heat medium which has been heated to a desired temperature in a heating device is circulated so as to preheat the steel strip to a higher temperature than that reached in the first preheating stage.

Patentansprüche

1. Verfahren zur kontinuierlichen Wärmebehandlung eines Stahlbandes, bei welchem das Band vorerwärmt und dann in einer Heizzone mittels mit verbranntem Abgas beheizten Strahlungsröhren indirekt erwärmt wird, dadurch gekennzeichnet, daß das Vorwärmen progressiv in zwei Stufen erfolgt, wobei das Band in der ersten Stufe nur auf eine vorbestimmte erste Maximaltemperatur durch direkten Kontakt mit einem gasförmigen Strom erwärmt wird, welcher in einem Wärmetauscher durch das verbrannte Abgas aus der Heizzone erwärmt wird, und in der zweiten Stufe das vorerwärmte Band aus der ersten Vorwärmstufe auf eine gewünschte zweite Temperatur, die höher als die erste Maximaltemperatur ist, weitererwärmt wird, indem das Stahlband über Heizrollen geführt wird, durch welche ein Heizfluid zirkuliert, das in einer Heizeinrichtung auf eine gewünschte Temperatur erwärmt wird, die ausreicht, daß das Band in der zweiten Vorwärmstufe auf die gewünschte höhere Temperatur erwärmt wird, bevor es in die Heizzone eintritt, wodurch eine wellenförmige Bewegung des Stahlbandes wesentlich reduziert wird.

2. Verfahren nach Anspruch 1, worin der in der ersten Vorwärmstufe verwendete gasförmige Strom ein sauerstoffhältiger Strom ist und die vorbestimmte erste Maximaltemperatur so geregelt wird, daß die

Bildung eines dicken Oxidfilms auf dem Stahlband verhindert wird.

3. Verfahren nach Anspruch 1 oder 2, worin die zweite Vorwärmstufe in einer nicht oxidierenden Atmosphäre durchgeführt wird.

4. Verfahren nach Anspruch 1, 2 oder 3, worin die vorbestimmte erste Maximaltemperatur 250 °C beträgt und die gewünschte höhere zweite Temperatur im Bereich von 250 bis 500 °C liegt.

5. Verfahren nach Anspruch 1, 2, 3 oder 4, worin das in der zweiten Vorwärmstufe verwendete Heizfluid schmelzflüssiges Nitrat ist.

6. Verwendung eines progressiven zweistufigen Vorwärmverfahrens eines Stahlbandes zwecks Minimierung einer wellenförmigen Bewegung des Stahlbandes bei der kontinuierlichen Wärmebehandlung des Stahlbandes durch indirektes Erwärmen mittels Strahlungsröhren in einer Heizzone, wobei das erste Vorwärmen durch direktes Beheizen mit einer gasförmigen Atmosphäre, die durch Wärmeaustausch mit verbranntem Abgas aus der Heizzone gewonnene fühlbare Wärme enthält, bewirkt wird, und das zweite Vorwärmen mittels Heizrollen, durch welche ein in einer Heizeinrichtung auf eine gewünschte Temperatur erwärmtes Wärmefluid zirkuliert, bewirkt wird, sodaß das Stahlband auf eine höhere Temperatur als in der ersten Vorwärmstufe erwärmt wird.

Revendications

1. Procédé pour recuire en continu un feuillard, dans lequel on chauffe préalablement le feuillard et on le chauffe ensuite indirectement dans une zone de chauffage au moyen de tubes rayonnants chauffés par des gaz brûlés, caractérisé en ce que l'on effectue le préchauffage progressivement en deux étapes, au cours de la première desquelles on chauffe le feuillard jusqu'à une température qui n'est pas supérieure à une première température prédéterminée maximale par contact direct avec un courant gazeux qui a été chauffé dans un échangeur de chaleur au moyen des gaz brûlés provenant de la zone de chauffage, et au cours de la seconde desquelles le feuillard préchauffé provenant de la première étape de préchauffage est en outre chauffé jusqu'à une seconde température désirée plus élevée que ladite première température maximale par enroulement du feuillard sur des cylindres chauffés à travers lesquels on fait circuler un fluide de chauffage qui a été chauffé dans un dispositif de chauffage jusqu'à une température suffisante pour que celle du feuillard au cours de la seconde étape de préchauffage augmente jusqu'à ladite température plus élevée désirée avant de pénétrer dans la zone de chauffage, grâce à quoi le mouvement sinueux du feuillard se trouve sensiblement réduit.

2. Procédé selon la revendication 1, dans lequel le courant gazeux utilisé au cours de la première étape de préchauffage est un courant contenant de l'oxygène et la première température prédéterminée maximale est réglée de manière à empêcher la formation d'un film épais d'oxyde sur le feuillard.

3. Procédé selon la revendication 1 ou 2, dans lequel on effectue la seconde étape de préchauffage dans une atmosphère non oxydante.

4. Procédé selon la revendication 1, 2 ou 3, dans lequel la première température prédéterminée maximale est 250 °C et la seconde température désirée plus élevée est comprise entre 250 et 500 °C.

5. Procédé selon la revendication 1, 2, 3 ou 4, dans lequel l'agent fluide de chauffage utilisé au cours de la seconde étape de préchauffage est un nitrate fondu.

6. Utilisation en deux étapes d'un préchauffage progressif de feuillard dans le but de minimiser le mouvement sinueux du feuillard au cours du recuit en continu de ce feuillard par chauffage indirect à l'aide de tubes rayonnants dans une zone de chauffage, le premier préchauffage étant effectué par chauffage direct à l'aide d'une atmosphère gazeuse contenant de la chaleur sensible récupérée par échange de chaleur avec les gaz brûlés en provenance de la zone de chauffage, et le second préchauffage étant effectué à l'aide de cylindres chauffés à travers lesquels on fait circuler un agent fluide de chauffage qui a été chauffé jusqu'à une température désirée dans un dispositif de chauffage de manière à préchauffer le feuillard jusqu'à une température plus élevée que celle atteinte au cours de la première étape de préchauffage.

FIG_1

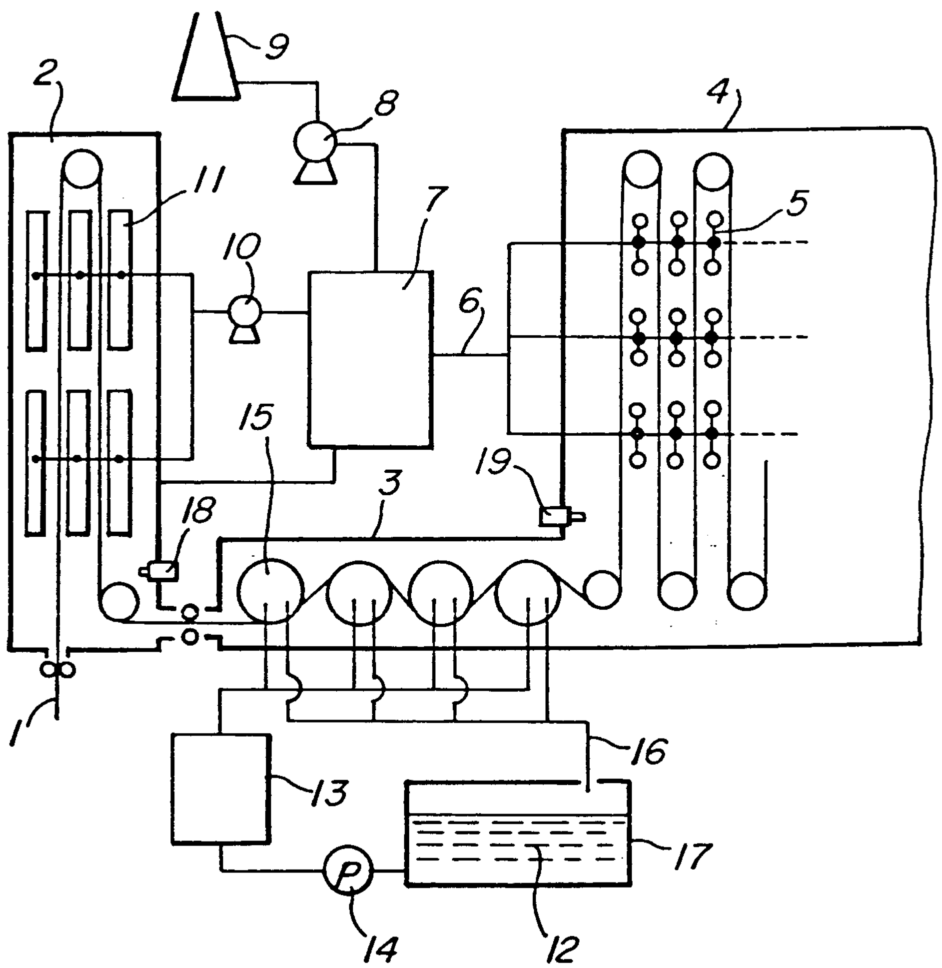


FIG. 2

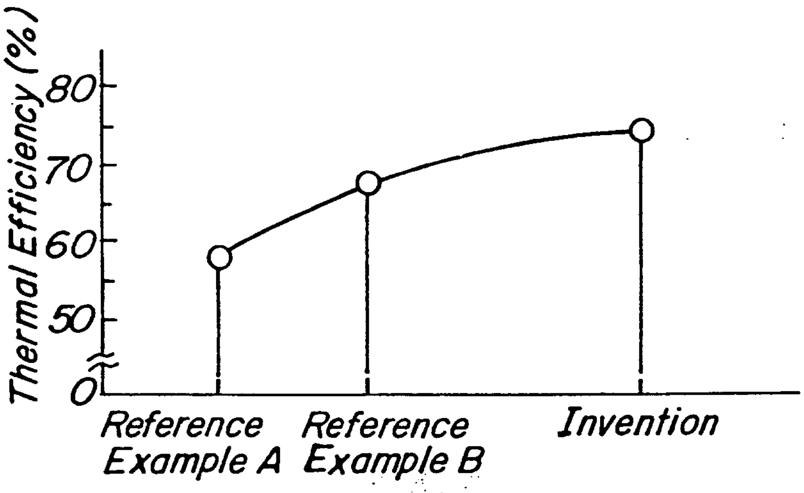

Thermal Efficiency (%)
80
70
60
50
0
Reference Example A
Reference Example B
Invention

FIG. 3

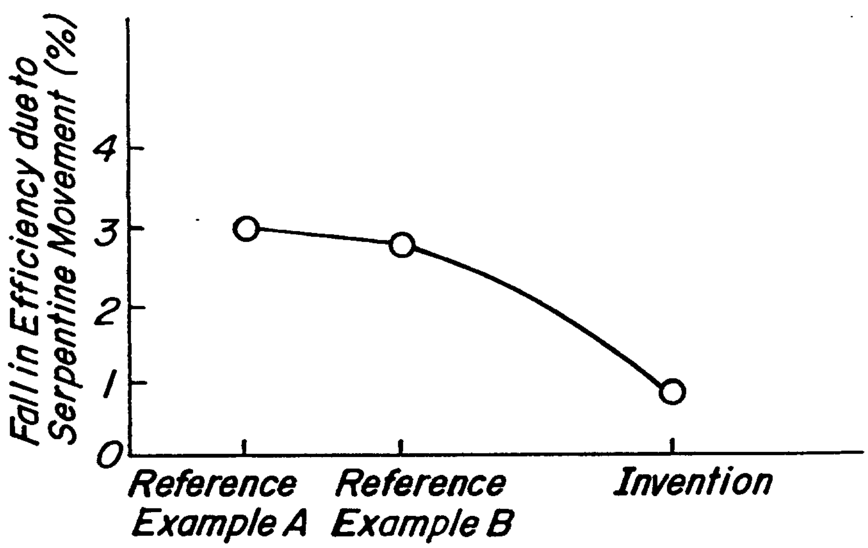

Fall in Efficiency due to Serpentine Movement (%)
4
3
2
1
0
Reference Example A
Reference Example B
Invention

FIG.4

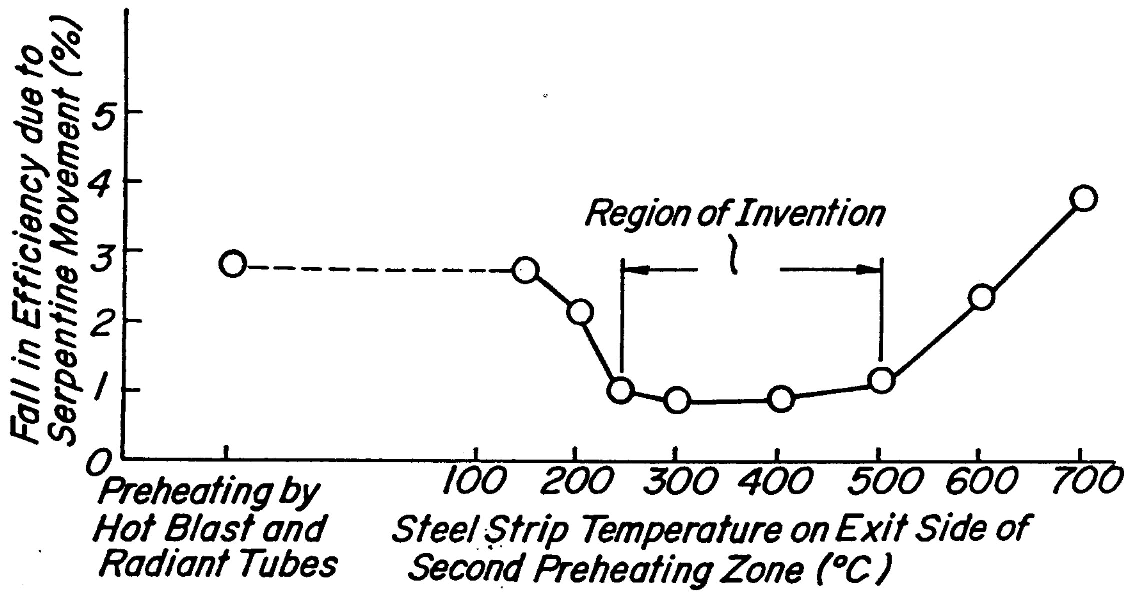

Fall in Efficiency due to Serpentine Movement (%)
0
1
2
3
4
5
Region of Invention
Preheating by Hot Blast and Radiant Tubes
100
200
300
400
500
600
700
Steel Strip Temperature on Exit Side of Second Preheating Zone (°C)

FIG.5

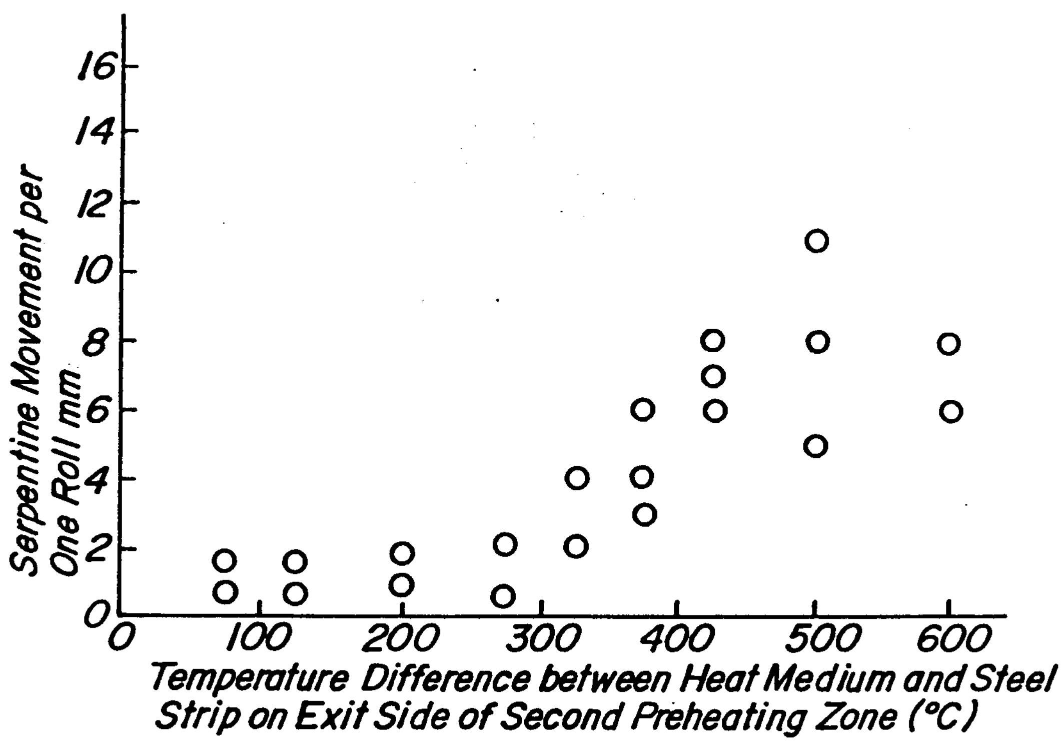

Serpentine Movement per One Roll mm
0
2
4
6
8
10
12
14
16
0
100
200
300
400
500
600
Temperature Difference between Heat Medium and Steel Strip on Exit Side of Second Preheating Zone (°C)

FIG. 6

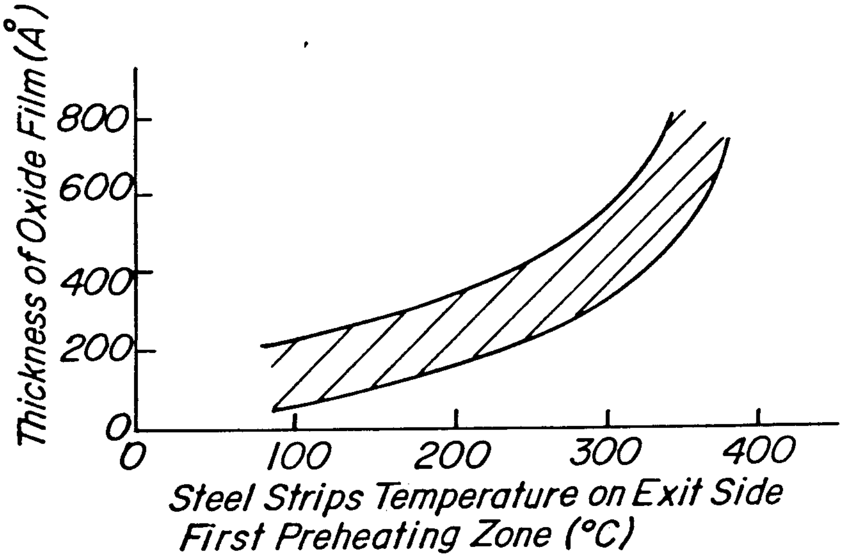

Thickness of Oxide Film (Å)
800
600
400
200
0
0
100
200
300
400
Steel Strips Temperature on Exit Side
First Preheating Zone (°C)

FIG. 7

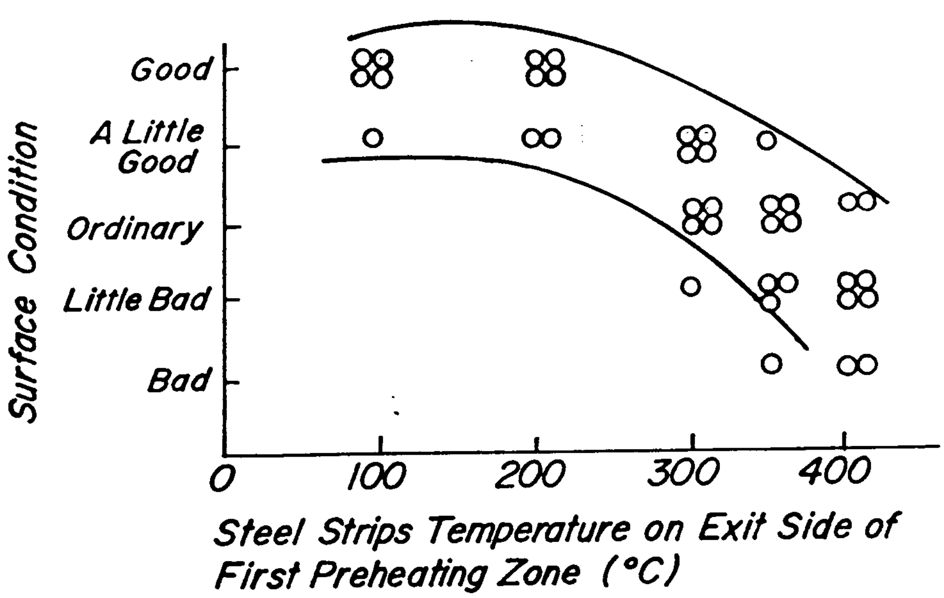

Surface Condition
Good
A Little Good
Ordinary
Little Bad
Bad
0
100
200
300
400
Steel Strips Temperature on Exit Side of
First Preheating Zone (°C)

FIG_8

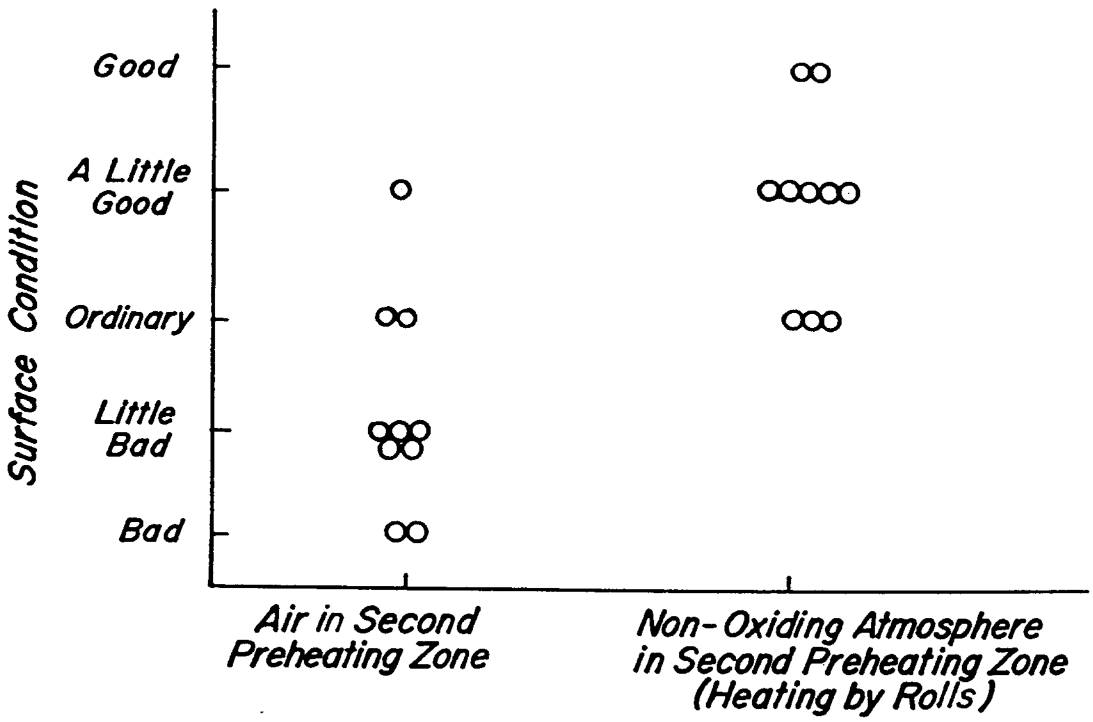
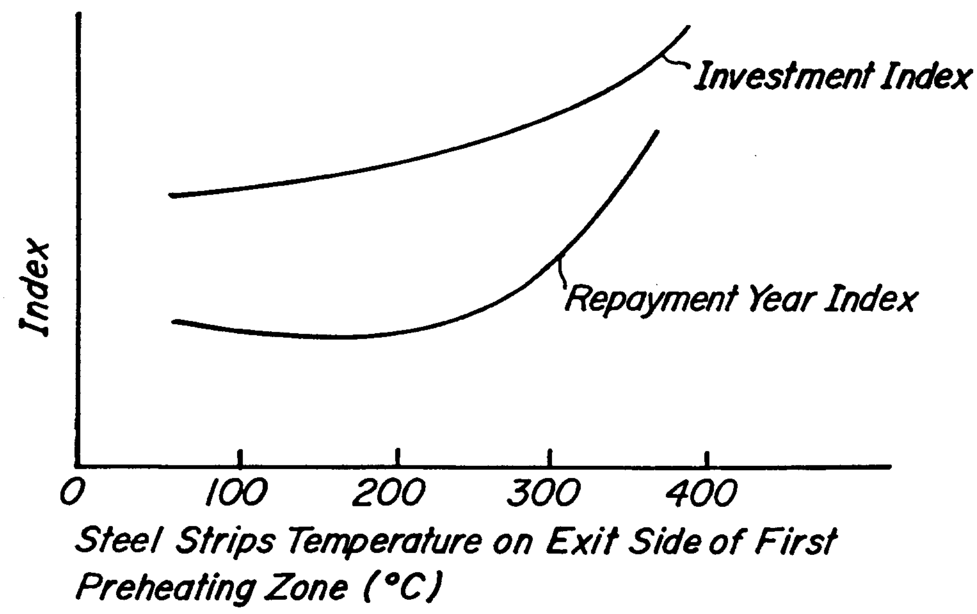

Surface Condition
Good
A Little Good
Ordinary
Little Bad
Bad
Air in Second Preheating Zone
Non-Oxiding Atmosphere in Second Preheating Zone (Heating by Rolls)

FIG_9


Index
Investment Index
Repayment Year Index
0
100
200
300
400
Steel Strips Temperature on Exit Side of First Preheating Zone (°C)