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STRIP HEATING

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The present invention relates to continuous strip heating furnaces such as those used for annealing strip brass or for brightening tin plate, and more particularly to a furnace in which steam is used as a heating medium.

In the continuous heating of strip metal such as the brightening of tin plate stock, for example, it is desired to bring the strip up to temperature rapidly, and to keep it at the required temperature for a relatively short period of time. If the strip is kept at a temperature where the tin is melted for too long a time, the tin coating will alloy with the steel base to such an extent that the quality of the finished strip is lowered.

In previous furnaces for brightening the surface of tin plate it has been difficult to control exactly the point where the tin melted and began to flow. Consequently in many cases the tin has been liquid for too long or too short a time. In the first case the quality of the strip was lowered due to alloying, as mentioned above, and in the second, the tin did not flow sufficiently to produce a bright, smooth surface.

Also, it has been difficult to heat evenly brass strip and tin plate, for example, because of the different heat absorbing characteristics of the sheet as its color varied due to dark spots or streaks or the like.

It is an object of the invention to provide a method and apparatus for accurately and rapidly heating strip metal to a desired temperature and evenly throughout its area.

It is a further object of the invention to provide apparatus for continuously brightening tinned strip. A further object of the invention is to use high temperature steam as a convection heating medium in the continuous heating of strip metal.

An additional object of the invention is to provide apparatus for brightening tin plate strip material in such a manner that the tin is melted and flows to a smooth, shiny surface immediately before it leaves the heating apparatus, and is quenched to solidify the tin shortly thereafter. The apparatus is operated in such a fashion that the tin is not molten long enough to alloy an undesirable amount with the base metal.

In accordance with the present invention the strip is moved vertically downward through a furnace chamber. As the strip is moved, in one form of the invention, it is heated by radiant heat and the convection heat produced by hot products of combustion to a point just below the point at which the tin coating will melt. The strip then has its temperature quickly raised to a point where the tin will flow by convection heat produced by a blast of superheated steam. The heating effect of the steam can be readily controlled, and is considerably greater than that of lighter gases because of its greater density. Shortly after the tin is melted the strip is cooled to set it, before it is brought into contact with any surface.

In another form of the invention all of the heating is accomplished by a plurality of blasts or jets of superheated steam that are projected directly and at high

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velocity against the surfaces of a continuously moving strip.

The invention will be described as it is used for the brightening of tin plate stock. It will be obvious, however, that the invention can be used to advantage in heating other types of strip material such as brass, for example.

The various features of novelty which characterize my invention are pointed out with particularity in the claims annexed to and forming a part of this specification. For a better understanding of the invention, however, its advantages and specific objects attained with its use, reference should be had to the accompanying drawings and descriptive matter in which I have illustrated and described a preferred embodiment of the invention.

In the drawings:

Fig. 1 is a vertical section view of one form of the invention,

Fig. 2 is a section view showing in perspective the steam distributing device,

Fig. 3 is a section view of a modified form of the invention, and

Fig. 4 is a section view of a modified form of the steam distributing device.

Referring to Figs. 1 and 2 of the drawing, there is shown a furnace 1 having a chamber 2 through which a strip 3 is moved downwardly in a vertical direction into a quench tank 4. The strip is guided by rollers 5 through this tank to a point at which it can be cut into lengths or coiled as desired.

The furnace can be similar in construction to that shown in Patent 2,573,019, issued October 30, 1951, to the present applicant, and has a vertically elongated chamber that is substantially rectangular in section with the rectangle having a length slightly greater than the width of the strip to be heated. Furnaces of this type include a metal backing 6 that is lined with refractory material 7. The opposed walls of the furnace are provided with a plurality of horizontal rows of burners 8. These burners are each provided with a cup-shaped depression 9 formed on the surface of the furnace wall into which a combustible mixture of the fuel and air is discharged by a distributor 11. The distributors are connected preferably to a manifold 10 for each row of burners, and the manifolds are connected to a common supply of fuel mixture.

Generally a valve is placed in the supply line to each manifold, and between the manifolds and each burner so that the pattern of heat supply can be easily adjusted. The fuel and air mixture is discharged in a plurality of substantially radially directed jets which burn along the surface of the cup to heat the same to incandescence. Heat is imparted to the strip in the form of radiant heat from the cups of the burners, and in the form of convection heat from the hot products of combustion. If desired the opposite sides of the furnace can be made separately so that they can be moved relative to each other away from the strip in order to provide access to the furnace chamber for maintenance and repair.

At the lower end of the furnace, and immediately adjacent to the exit thereof, there is provided a pair of steam ejector devices 12 which are adapted to discharge high velocity blasts of superheated steam in the form of a sheet against the surfaces of the strip to bring the strip to the final desired temperature. As shown herein, devices 12 are located outside what could be considered the furnace chamber proper, but they could be located within the chamber if desired. It is only necessary that the strip be beyond the burners before it passes in front of devices 12. Each of the steam ejector devices is elongated, as shown in Fig. 2, and extends across the furnace for a width at least equal to the width of the strip being treated. The construction of these ejector devices is shown in detail in Fig. 2.

Each of the ejector devices is identical and is provided with an elongated casing 13 that serves as a manifold and which extends for the full length thereof. The casing is provided along its rear with a plurality of inlets 14 for a gas-air mixture. The outer edges of this casing are provided with shoulders that locate an inlet screen formed of a plurality of face to face ceramic plates 15. Each plate is provided on one face thereof with a plurality of grooves 16 which cooperate with a flat face of the next adjacent plate to provide a plurality of passages through which the gas-air mixture can flow. It is noted that the plates 15 are provided on their rear edges with shoulders 17 that are received in the shoulders on the base casing. The jets of gas and air discharged through passages 16 flow into an elongated combustion chamber 20 formed by a pair of refractory plates 18. These plates bend toward each other at their outer ends as best shown in the drawing to provide a combustion chamber which has a restricted discharge slot 21. Plates 15 are held in position against casing 13 by elongated metal strips 19, and the refractory walls 18 of the combustion chamber 20 are held in position by a hollow upper casing 22 and a hollow lower casing 24. Screws are provided which extend through flanges on the casing 13, through strips 19, and into a back wall of the casings 22 and 24, respectively, in order to hold the parts in assembled relation as shown in Fig. 2 of the drawings.

Casing 22 is hollow and is provided with a plurality of inlets 23 for steam while the casing 24 is hollow and is provided with a plurality of inlets 25 for steam. The casings 22 and 24 act as a steam jacket for combustion chamber walls 18. Steam that is supplied to the hollow casings is exhausted through a plurality of ports 26 which extend along the edges of a slot 27 that is aligned with exhaust slot 21 of combustion chamber 20 of the device. If it is desired or found to be necessary baffles can be placed in the interior of the combustion chamber and in the interior of the casings 22 and 24 in order to give them added strength and to insure the proper distribution of the fluids that pass therethrough. It is also noted that valves 28 and 29 are used to control the flow of steam respectively into the casings 23 and 25 while a valve 24 is used to control the flow of combustible mixture into the casing 13.

The supply of fuel and gas to the burners 8 comes from a series of pipes and manifolds which are so arranged that the burners in the various rows on opposite sides of the furnace can be individually adjusted as desired. Thus each row of burners through its manifold, can be adjusted to give a desired amount of heat so that the entire set of burners will heat the strip to the proper temperature by the time it reaches the bottom of chamber 2. Fuel in the form of a combustible mixture of gas and air is supplied to the casings 13 of devices 12, and passes through passages 16 in the screen 15 to the combustion chamber 20 of these devices. At this point the fuel mixture is burned completely and the hot products of combustion are discharged at high temperature and high velocity through the restricted outlet 21. Simultaneously, steam is supplied through the inlets 23 and 25 respectively, at a rate determined by the opening of valves 28 and 29. This steam is heated by the heat conducted through the walls 18 of the combustion chamber and is discharged substantially as a jet through openings 26 across the exhaust opening 21. At this point the hot products of combustion, which are in the neighborhood of 3,000° F., strike the steam and superheat it to a high degree. The hot products of combustion also force the steam at high velocity against the strip where the steam will give up some of its heat to the strip.

In the operation of the apparatus a strip, as electroplated strip steel used in the making of tin plate, is moved downwardly through the furnace chamber and past the outlets 27 of devices 12. The burners 8 of the

furnace are so adjusted that the strip during its travel in front of them will be raised to a temperature slightly below the temperature (between 15 and 25° F.) at which the tin coating on the strip will be melted. As this preheated strip passes in front of the devices 12, the superheated steam will strike the strip and raise its temperature almost instantaneously to a temperature above which the tin will be melted. This temperature will be approximately 470° F. The tin will therefore be raised to its melting point at a given position with respect to the level of the quench tank. Thus the tin will be melted a predetermined length of time before it is quenched.

The high rate at which heat can be transferred from the steam to the strip permits the construction of apparatus in which a definite point of melting of the tin is possible. By locating the quench tank a given distance below the steam discharge devices, the necessary time required for the tin to flow smoothly into a bright, shiny surface can be obtained without the indeterminate time required in other types of tin flowing apparatus. The fact that the tin remains melted for only so long as is required for it to flow evenly insures that undesirable alloying with the base metal will not take place. The steam will encase the strip to protect its surface between the time the tin is melted and is quenched. Some of the steam will flow into the furnace chamber and, because of its density, will create an atmosphere that will increase the rate of heat transfer to the strip. For some metals water vapor in the furnace chamber may be detrimental. This is not the case, however, for tinplate or brass.

The embodiment disclosed in Fig. 3 of the drawings accomplishes the same result as that disclosed in Fig. 1 and described above. This form of the invention differs from the one previously described, however, in that all of the heating of the strip is accomplished by the steam ejector devices 12. As shown in Fig. 3, there are a plurality, in this case four, of the steam ejector devices extending across each side of the strip. The actual number of devices used will vary depending upon the speed of travel of the strip. These devices are identical to that disclosed in Fig. 2, except that the steam casings adjacent to each other in the top three devices on each side of the strip are shown as being supplied by a single supply pipe 32. The bottom device on each side of the strip has both the upper and lower steam casings supplied by individual steam supplies as did the ejector devices in Fig. 1. The devices are mounted in a furnace structure similar to that shown in connection with Fig. 1, in that there is provided a sheet metal backing 6 and refractory material 7 forming the lining of the furnace chamber. It will be seen that there is an elongated furnace chamber which has projecting toward each side of the strip to be heated, a plurality of the steam ejecting devices.

In the operation of this embodiment the supplies of steam and fuel mixture to the upper three steam ejecting devices on each side are adjusted to raise the temperature of the strip to a point just below that at which the tin coating will be melted. These devices can be adjusted together or individually to give a heating value that will be coordinated with the speed of the strip in order to raise the temperature of the strip to the proper value slightly below the melting point of the tin. The final devices, as in the embodiment of Fig. 1, raise the temperature of the strip to approximately 470° F., or slightly above the melting point of tin, so that the tin will flow smoothly into a bright surface prior to the time it is solidified in the quench tank 4. It is intended that the supplies of fuel and steam to the bottom devices should be adjusted individually to give the correct temperature to the strip.

Another form that the steam ejector devices can take is disclosed in Fig. 4 of the drawings. In this form there is provided a base casing 34 into which the combustible

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mixture of air and gas is supplied. This casing is provided with shoulders to receive the shoulders 35 on the edges of a screen formed of plates 36 that are similar to the plates 15 in the form of the invention shown in Fig. 2. These plates are also provided with grooves 37 on one face thereof that will cooperate with a flat face of the next adjacent plate to form passages through which the fuel mixture can flow. Various of these plates are also provided with additional passages indicated at 38 through which a pipe will extend for a purpose indicated below. The various plates are held against the shoulder of casings 34 by means of metal strips 39 that extend along the device. To the right of the plates 36 there is provided a pair of refractory plates 41 which serve to form a combustion chamber 42 that has a restricted outlet 43. These plates are held in position by a pair of casings 44 as best shown in the drawings. Each casing 44 is attached to strips 39 and the casing 34 to hold the entire assembly together by means of suitable bolts 45 which extend through flanges on the casing 34, strips 39, and flanges on the casings 44.

The casings 44 preferably in communication at their ends, and, if desired, at some intermediate point so that they form a steam jacket around the combustion chamber. Steam is supplied to the casing 44 through one or more pipes 46 and passes through the lower and the upper casings to be discharged through one of a series of outlet pipes 47 that are located at various points along the length of the device. These outlet pipes connect with a manifold 48 so that the steam which is supplied through inlet 46, and which is additionally heated by the heat transmitted from the combustion chamber through the refractory walls 41, is collected in the manifold 48. A plurality of pipes 49 are connected with the manifold 48 and extend through the back of casing 34 and openings 38 provided in the plates 36 into the combustion chamber to a point adjacent to exhaust opening 43. Thus the steam is surrounded by the hot products of combustion as they are discharged through opening 43 against the surface of the strip. These hot products of combustion further superheat the steam and increase its velocity so that it is projected against the surface of the strip as a sheet with quite a bit of force. Thus the rate of heat transfer from the steam to the strip is high.

From the above description it will be seen that I have provided apparatus for heating a strip of material which apparatus is particularly adapted for the flowing of tin on tin plate. The strip is heated in a plurality of steps with the first step raising the temperature of the strip to a point just below the melting point of the tin. The second step is used to bring the strip temperature above the melting point of the tin coating at a particular point in its path of travel and is accomplished by a high temperature, high velocity jet of steam which impinges upon the surface of the strip. The relatively great heat transfer that is obtained by the use of superheated steam insures

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that the strip temperature will be raised rapidly and uniformly to the desired value. The steam also serves to encase the strip and prevent any oxidation on the surface thereof.

While in accordance with the provisions of the statutes, I have illustrated and described the best form of embodiment of my invention now known to me, it will be apparent to those skilled in the art that changes may be made in the form of the apparatus disclosed without departing from the spirit and scope of the invention set forth in the appended claims, and that in some cases certain features of my invention may be used to advantage without a corresponding use of other features.

What is claimed is:

1. The method of heating continuously bright tin plate strip metal which comprises moving the strip through a path, applying radiant heat to opposite sides of the strip to raise its temperature to a degree slightly below the temperature at which tin melts, and discharging superheated steam at high velocity in a sheet against opposite sides of the strip at a fixed line across the strip at a location in said path beyond the point at which the radiant heat has been applied thereto, and before any appreciable loss of the radiant heat from the strip can take place, to bring the strip rapidly to a temperature above the melting point of tin.

2. The method of claim 1 including the step of quenching the strip continuously a predetermined time after it has been brought to its final desired temperature.

3. The method of heating continuously bright non-ferrous strip metal which comprises moving the strip through a path, applying radiant heat to opposite sides of the strip to raise its temperature to a degree slightly below the annealing temperature of the strip, and discharging superheated steam at high velocity in a sheet against opposite sides of the strip at a fixed line across the strip at a location in said path beyond the point at which the radiant heat has been applied thereto, and before any appreciable loss of radiant heat from the strip can take place, to bring the strip to its annealing temperature.

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