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METHOD OF DRAWING STAINLESS STEEL WIRE

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9 Claims. (Cl. 148—6.35)

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This invention is concerned with the art of cold drawing wire from stainless steel rod and wire stock having scale on its surface of the type produced by hot working and annealing under oxidizing conditions. This type of scale is formed on stainless steel rod hot rolled from a billet in air in the currently conventional manner, and also by annealing stainless steel rod and wire when no effective protection is provided against air while it is at annealing temperatures. It is the type of scale which prior to this invention had to be removed by pickling before the steel could be cold drawn into wire through a wire drawing die, because its brittle and abrasive nature made drawing through dies commercially impracticable. The stainless steel with which the invention is concerned is any of the ferritic grades containing at least 12% chromium and any of the austenitic grades, all of these grades producing the described scale type in forms that make it harder to remove than do the forms produced on plain carbon and low alloy steels, and which make it more destructive to wire drawing dies. Also, these stainless grades are inherently harder to draw than the other steels named, and prior to this invention they not only required more expensive pickling to remove the scale, but also required the extra steps of lead coating to permit their drawing, and the subsequent removal of the lead.

My invention provides a process for treating this type of scale so that it may not only be left on stainless steel rod and wire during cold drawing through a wire drawing die, but also that it will be conditioned to permit drawing of such rod and wire without lead coating the latter.

The principles of the invention may be understood from the following description of specific examples.

To cite one example, ferritic stainless steel of the straight 12% chromium grade is hot rolled in air from a billet into a $\frac{5}{16}$ inch diameter rod in the currently conventional fashion so its surface has the described type of scale. Then the cold rod bundle is immersed in a strongly alkaline water solution heated to from 180° F. to boiling temperature, the bundle being left in this solution for from 20 to 30 minutes. Next, while still wet with such a solution, the bundle is limed in the usual manner excepting that baking is necessary only to dry the lime solution. Finally, the rod from the bundle is dry drawn through tungsten carbide wire drawing dies using a lubricant consisting by weight of 80% calcium stearate, 15% graphite and 5% dry lime intimately mixed so as to coat the graphite particles with the calcium stearate, the drawing preferably involving heavier reductions in the first draft and with the succeeding draft reductions becoming lighter by comparison with the first, as the drawing progresses and the stock work hardens. The rod is $\frac{5}{16}$ inch diameter and it is drawn in three drafts down to .192 inch diameter before annealing is required by the work hardening effect. Annealing is then carried out without cleaning the stock and with air contacting the stock at annealing temperatures to develop more of the described type of scale, and the stock is then again treated, limed and lubricated as described and drawn down in one draft to .1875 diameter which is the finished size. At this time simple acid cleaning with a water solution of either hydrofluoric, hydrochloric, sulphuric acids, etc., suffices to remove the scale, lime and lubricant left on the finished wire.

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As a second example, austenitic stainless steel of the 18–8 grade is similarly hot rolled into rods having a diameter of $\frac{5}{16}$ of an inch, but since this grade must be stabilized against carbide precipitation by quenching from temperatures around 2100° F., the rod is heated to these temperatures and then quenched by passing it continuously through a strongly alkaline water solution to both stabilize it and condition its scale for drawing, as was done in the first example by the more prolonged immersion. That is to say, ferritic steels cannot be quenched because they would harden, so the bundle is immersed cold into the heated solution and so requires time to heat to the solution temperature, while austenitic steels often must and always can be quenched from very high temperatures. In the case of austenitic steel, therefore, it is enough to let the solution contact the rod for 5 seconds, remembering the continuous nature of the immersion, and when removed the heat left in the rod dries it. Therefore, the rod is again wet with the solution before the liming, or is treated with some other agent promoting wetting of the rod with the lime solution during liming. It has been found preferable in all instances to have the rod wet with some good wetting agent prior to liming. Otherwise than noted, the 18–8 rod may be drawn and cleaned as was the straight 12% chromium grade.

Now it will be noted that these examples show that one characterizing feature of the invention is the discovery that the scale which in commercial practices is always formed as the result of processing the steel into rod or by its heat treatment and which has caused so much trouble in the past is conditioned so that it not only ceases to cause trouble, so it need not be removed, but also actually substitutes for the lead coating formerly necessary when the higher alloy stainless steel grades were die worked. It is thus pertinent to more fully discuss the strongly alkaline water solution used for this conditioning.

This solution may be made of any alkaline substance providing the solution with sufficient al-

kalinity, and the degree of alkalinity may be determined simply by following the procedure described and adjusting the alkalinity until a value is found which makes possible successful drawing of the scaled rod. The required degree of alkalinity varies with the immersion time of the scaled rod in the solution and with the solution temperature, a lower degree being required with longer immersion time and higher temperatures and vice versa. However, the time in both batch handling and continuous immersion is limited in commercial work, and the solution temperature cannot exceed its boiling point, so the solution should be strongly alkaline. To examplify, by using a commercially available alkaline detergent consisting by weight of 42.86% Na_2CO_3, 7.41% NaOH, 2.85% $Na_2Si_4O_9$, 14.22% $Na_3Po_4.2H_2O$ and 32.66% rosin soap; from 5 to 8 ounces of this detergent to a gallon of water provides a degree of alkalinity making effective the time values given in the two specific examples. A water solution of sodium hydroxide or sodium carbonate providing a similar degree of alkalinity may be substituted. Another commercial available alkaline detergent consists by weight of 41.40% Na_2CO_3, 29.60% $Na_3PO_4.2H_2O$ and 29% rosin soap; and about 5 to 8 ounces per gallon of water provides a solution that is also effective. In no event should the immersion time be so long as to remove substantial amounts of the scale being treated to make it substitute for lead coating during the drawing.

As indicated, it is important that such a solution also be used to wet the rod and wire stock prior to liming, but this solution may be applied to the scaled stock cold when considered only for use as a wetting agent during the liming. If possible the stock is preferably limed while still wet from its treatment with the solution at elevated temperature to condition its scale for drawing, but if it dries it should be rewet with the solution or its equivalent prior to the liming.

The lubricant used must be of such a nature as to function as a wire drawing lubricant under the heavy pressures and consequently high temperatures encountered in drawing the high alloy stainless steel grades here involved, and the one specifically described does this. Others may be substituted providing they do not fail to function as a wire drawing lubricant during the cold drawing through the wire drawing die. For instance, any metallic stearate and graphite may be used, if the graphite is covered with the stearate.

In the foregoing it is to be noted that certain annealings under oxidizing conditions are mentioned, and these may be for the usual purposes common to the prior art. Thus, in the case of the straight chromium stainless ferritic steel type, although not mentioned before, it is common to batch anneal the hot-rolled rod bundles by passing them through a continuous furnace directly heated by flames from burners supplied with natural gas to normalize the steel by heating it to from about 1500° to 1700° F., and slowly cooling it, prior to any drawing, and, as specifically mentioned, to anneal the wire in process when it work hardens to a degree requiring this, and here again the process wire in coils is batch annealed continuously as described. As to the austenitic type, the practice is to anneal the hot-rolled rod or process wire bundles by causing the rod or process wire to continuously uncoil and pass through a similar continuous furnace as a single strand, so it is heated to around 2100° F.,

whereupon it is quenched continuously upon leaving the furnace, this being for the reason described and also because this is the way the austenitic stainless steel types must be annealed even when chemically stabilized against carbide precipitation.

Both types of furnaces are provided with air and gas valves for controlling the gas-to-air ratio of the gas and air mixture fired by the open flame burners inside the furnace, and it is common in the art to say that the furnace atmosphere, provided by the air leaking into the furnace and the products of combustion, is oxidizing, neutral or reducing, depending on whether the air is excessive, just sufficient, or insufficient, for complete combustion of the natural gas, these terms applying to the nature of the atmosphere respecting iron but still being used when the steel is stainless even though the atmosphere is always oxidizing to varying degrees respecting all stainless steels.

Using the above terminology, the usual method of operating such furnaces, in heating stainless steel for annealing, has been to use an oxidizing atmosphere, this meaning too much air for complete combustion, because this tends to give maximum heating and also aids in the removal by pickling of the scale whether it is already on the steel or is formed during the heating in the furnace. Naturally this practice was followed in the case of the described recent method of cold die working stainless steel with the scale on its surface, there having been no known reason for departing from the practice.

According to the present invention, the scaled hot-rolled stainless steel rod of either the ferritic or austenitic types is annealed prior to the described conditioning of its scale, in one or the other of the described types of furnaces with the furnace air and gas valves adjusted to provide a furnace atmosphere that is at least slightly reducing respecting iron or, more specifically, so it contains from a fraction of one per cent up to about six or seven per cent of carbon monoxide in excess of that which can be burned with the air available in the furnace at the burners. Preferably, about 2% excess carbon monoxide is provided, since greater amounts make the furnace produce a noticeable amount of smoke annoying to the furnace operators. The flame in the furnace should be at least a little smoky. Such a furnace atmosphere is still oxidizing respecting stainless steel although it is commonly termed "reducing" because of the practice of using iron as a standard. It will put the described type of scale on stainless steel if it is not already present. With the present invention, the furnace air and gas valves are also adjusted to give such a reducing atmosphere during the annealing of the process wire or of cleaned wire to be further drawn, and this practice is followed in the case of both the ferritic and austenitic types of stainless steel.

Except for the foregoing difference, the recently developed method of cold die working scaled stainless steel is practiced as described, but in the case of the present invention it will be found that because of this difference the treatment in the alkaline water solution unexpectedly results in a critically improved scale of markedly better cold die drawing characteristics. It has better adherence to the rod or wire and is less abrasive to the dies. This is so even when normally scaled hot-rolled rod is annealed as described, the annealing in an atmosphere having

excess carbon monoxide, or which is reducing in the terminology of the art, cooperating with the described conditioning to attain this new and unexpected result in all instances.

As used in the specification and claims, the term "scaled" is intended to mean that the stock carries a substantial surface coating of oxide.

I claim:

1. In the art of cold die working stainless steel stock having scale on its surface of the type produced by its hot working and annealing under oxidizing conditions, the improvement comprising annealing said scaled stock in a slightly reducing atmosphere respecting iron, thereby changing the character of the scale, contacting said scale on said annealed stock with a strongly alkaline water solution at elevated temperature for a time less than that required to remove substantial amounts of said scale from said stock, lubricating the scaled stock and cold die working the scaled and lubricated stock.

2. In the art of drawing wire from austenitic stainless steel rod and wire stock having the scale on its surface of the type produced by its hot working and annealing under oxidizing conditions, the improvement comprising heating said scaled stock to a temperature where its carbides are in solution in a slightly reducing atmosphere respecting iron to change the character of the scale and then quenching it by continuously passing it through a strongly alkaline water solution, liming the scaled stock, lubricating the scaled and limed stock, and cold drawing the scaled, limed and lubricated stock through a wire drawing die.

3. In the art of drawing wire from ferritic stainless steel rod and wire stock having scale on its surface of the type produced by its hot working and annealing under oxidizing conditions, the improvement comprising annealing said scaled stock in a slightly reducing atmosphere respecting iron, thereby changing the character of the scale, immersing the scaled stock in a strongly alkaline water solution at temperatures between 180° F. and its boiling point for from 20 to 30 minutes, liming the scaled stock, lubricating the scaled and limed stock, and cold drawing the scaled, limed and lubricated stock through a wire drawing die.

4. In the art of drawing wire from stainless steel rod and wire stock having scale on its surface of the type produced by its hot working and annealing under oxidizing conditions, the improvement comprising annealing said scaled stock in a slightly reducing atmosphere respecting iron, thereby changing the character of the scale, contacting the scale with a strongly alkaline water solution at elevated temperature, liming the stock while wet with this solution, lubricating the scaled and limed stock with a mixture of metallic sterate and graphite with the metallic stearate coating all the graphite particles, and cold drawing the scaled, limed and lubricated stock through a wire drawing die, the alkalinity, temperature and time of said contacting being adjusted so the scale draws through said die.

5. In the art of die-working stainless steel stock, the improvement comprising annealing said stock in an atmosphere of combustion gases containing about 2% carbon monoxide so as to form a scale thereon, contacting the scale on said annealed stock with a strongly alkaline water solution at elevated temperature for a time less than that required to remove substantial amounts of said scale from said stock, lubricating the scaled stock and die-working the scaled and lubricated stock while cold.

6. In the art of drawing wire from austenitic stainless steel rod and wire stock, the improvement comprising heating said stock to a temperature at which substantial amounts of its carbides are in solution, in an atmosphere of combustion gases containing from a fraction of 1% to 6% carbon monoxide so as to form a scale on the said stock and then quenching it by continuously passing it through a strongly alkaline water solution, liming the scale stock, lubricating the scaled and limed stock, and cold-drawing the scaled, limed and lubricated stock through a wire-drawing die.

7. In the art of drawing wire from ferritic stainless steel rod and wire stock, the improvement comprising annealing said stock in an atmosphere of combustion gases containing from a fraction of 1% to 6% carbon monoxide so as to form a scale thereon, immersing the scaled stock in a strongly alkaline water solution at temperatures of from 180° F. to its boiling temperature for from 20 to 30 minutes, liming the scaled stock, lubricating the scaled limed stock, and cold-drawing the scaled, limed and lubricated stock through a wire-drawing die.

8. In the art of drawing wire from stainless steel rod and wire stock, the improvement comprising annealing said scaled stock in an atmosphere of combustion gases containing from a fraction of 1% to 6% carbon monoxide so as to form a scale thereon, contacting the scale with a strongly alkaline water solution at elevated temperature, liming the stock while wet with this solution, lubricating the scaled and limed stock with a mixture of metallic stearate and graphite with the metallic stearate coating all the graphite particles, cold-drawing the scaled, limed and lubricated stock through a wire-drawing die without lead coating the stock, and controlling the alkalinity and temperature of said solution and the time of contact therewith so the scale draws through said die and substitutes for a lead coating.

9. In a method of drawing stainless-steel wire, the steps including annealing stainless-steel wire stock in an atmosphere of combustion gases containing from a fraction of 1% to 6% carbon monoxide, thereby forming on the stock an adherent scale, subjecting the scaled stock to a strongly alkaline water solution for a time less than that required to remove a substantial amount of scale, thereby reducing the abrasiveness of the scale, liming the stock, then lubricating the stock and then cold-drawing it through a reducing die.

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