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PROCESS OF PRODUCING STAINLESS STEEL SHEET OR STRIP STOCK

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12 Claims. (Cl. 148—12)

General objects of our invention are to provide a process for the production of stainless steel strip or sheet stock which increases the yield of the material, which provides a better surface on the sheets, which saves power, which increases the life of rolling mill rolls and keeps them bright, clean and shiny, which permits the production of a greater tonnage on given apparatus and which therefore saves time and money per ton, and which eliminates certain picklings and annealings.

These general objects will be better understood from the description which follows. We accomplish them, and others which will be pointed out hereinafter, or will be apparent to the skilled rolling mill man, by certain variations in the usual procedure which we shall now describe by contrast with current practices.

Ingots of stainless steel usually vary in weight from say 5½ tons down to 3 tons, averaging about 8500 pounds. The average size is 17x42x66 inches. The composition of the ingots varies considerably. Some of them may comprise 18% of chromium, 8% of nickel, balance substantially all iron, others may have around 17% of chromium, with less nickel or none at all, balance being substantially all iron, or either of these exemplary analyses may additionally contain molybdenum or columbium or other materials. The size of the annealed ingot may be taken into account in variations of the hot rolling procedure in known manner. As to the analysis of the material, we have found that our process is applicable to all analyses of materials coming under the commercial classification of stainless steels.

In the accepted practice the stainless steel ingots are soaked in the usual manner, being thereby heated to rolling temperature. Then they are sent through a blooming mill. That is to say, they are rolled back and forth on a universal mill to produce a bloom which, by way of example, may be from approximately 17 inches down to 12½ inches in thickness.

The bloom is reheated and is then rolled down to a slab, say 2½ to 4 inches in thickness, 18 inches wide and 37 inches long, or any other suitable slab size depending upon the desired final gage and dimensions.

The slab is then permitted to cool and prior to any further rolling operations is usually thoroughly cleaned. This may be done by grinding its surfaces with swing grinders so as to erase all scabs, scale and the like.

After reheating the cleaned slab, it is the usual practice to reduce it by hot rolling on a universal mill to from ⅜ inch to ½ inch in thickness, depending upon the hot mills requirements for the finished gage. From 5 to 15 forward and reverse passes through the universal hot mill are usually given, depending upon the grade, the exigencies of subsequent reduction and the like. In our own commercial practice the material is then passed on down a table to a series of four-high hot finishing tandem mills and is there reduced to a gage for cold rolling which normally will be between .080 inch and a quarter inch, depending on the order. The tandem mill arrangement produces a strip which is then coiled.

The coiled strips are subsequently decoiled, welded together into a continuous strip, and then passed through a continuous annealing furnace. A pickling, washing, scrubbing and drying is next practiced upon the coils and, when they are recoiled, they are ready for cold reduction.

While we have thus far described a current and exemplary hot rolling process for producing intermediate gage material suitable for subsequent cold rolling, it will be understood that variations in the procedures are to be found both in the current art and in our novel process as hereinafter set forth. We do not modify the hot rolling procedures except in certain instances as to the hot rolled gage produced, all as we shall more fully explain hereinafter.

The cold reduction of stainless steel stocks involves certain serious problems. Heretofore it has been impossible successfully to cold roll stainless steels with more than a 40 to 50% reduction between annealings. Even with the best prior practices, a 50% reduction between annealings is all it is practical to make with stainless steel. From this point any further screwing down of the mill merely manifests itself in additional mill housing stretch or further deformation of the mill rolls. No greater general reduction in gage is produced; but localized reductions may impair the quality of the work piece. As a consequence, it is the usual practice, having brought the material to the hot gages above noted, to carry it down to finished thickness by a long series of cold rolling reductions with intermediate annealing and pickling treatments. With the usual cold reductions of say 40% in good practice for the first operations and somewhat lessened reductions for subsequent operations, from 4 to 6 or more stages have heretofore been found necessary. For example, in rolling stock which leaves the hot mill at the fairly light gage of .140 inch to a finish gage of .018 inch, it is standard practice to have as many as five annealings and picklings between the cold reductions.

We have found that by certain procedures and treatments we can reduce stainless steels without reannealings and repicklings by very much greater percentages of reduction, so that the number of heat treatments and cleaning steps is very greatly cut down. We accomplish this by producing on the surface of the sheets or strips a particular coating in a heat treatment, which coating enables us to make very much heavier cold rolling reductions. We do not wish to be bound by theory; but we believe that our coating acts as a lubricant in the cold rolling operation. It permits us to do more cold rolling on a hard sheet; and we do not get any "pick up" on the strip from the rolls while the strip is being rolled. In the old practices the scum on the rolls, which causes the rolls to grip the strip, prevents the metal from flowing, we believe, and therefore prevents further reduction in gage after approximately 50% reduction in the best practices. In our process the metal never stops flowing.

In an exemplary procedure under our invention, we handle the ingots, blooms and slabs in the usual manner and produce by hot rolling in usual way a strip or strip sheet. We find it advantageous, and good mill practice, to get as light a hot rolled gage as we can, dependent upon the required finished gage of the material. By way of illustration, let it be supposed that we have produced on the hot mills a material of a gage of .140 inch. We anneal and pickle this material in the usual way and then take it down to .070 inch on a tandem cold mill. This is a 50% reduction and is in line with the first cold rolling of the standard practices. It will be understood that the gages mentioned are, however, not limiting on our process.

But at this point we depart from standard practice by annealing the piece in a continuous furnace in a special procedure. And further, as a variant from standard practice, we do not pickle the strip after this annealing.

The purpose of the annealing is to produce on the strip an extremely thin, controlled film of oxide. This may be done in various ways, and is normally done by us through control of the furnace atmosphere so as to produce such a coating.

The oxide coating on the strip should be less than 1/1000 inch thick. It appears greenish in color and probably consists of or includes a chrome oxide or a chrome-nickel oxide. It is uniform over all surfaces of the strip or sheet, and is of such thinness that it is possible to see the cold rolled color of the stainless steel shining through it. The surface may be described as having a green-yellowish cast, but generally a metallic and shining appearance.

Such a coating may be made by passing a strip through a gas fired furnace and heating it to approximately 800° F.; and our invention includes such treatments. We prefer, however, to employ a more exact control by the use of special atmospheres in the furnace. The atmosphere which we prefer to employ is almost pure nitrogen, about 4% only of the gas being combustible. This gives approximately 2% hydrogen and approximately 2% CO. In our commercial practice we continuously recondition the gas in our furnace by recirculating it. In the recirculation cycle carbon dioxide and moisture are removed in any suitable way, as by passing the gas through activated alumina.

Other gases, however, may be employed. An annealing in hydrogen is possible; but we have found that nitrogen gives a brighter strip and apparently a somewhat more adherent oxide coating. Also mixtures of nitrogen and hydrogen with each other or with other gases are usable.

In our commercial practice the continuous furnace we employ is heated to between 1900 and 2000° F. The furnace itself is approximately 36 feet long. The strip moves continuously through the furnace at a speed predetermined in view of the gauge and grade of metal being worked. Our furnace is composed of four sections. The temperature in the first two sections is maintained between 1900 and 1950° and the temperature in the last two sections is about 1950° or slightly higher. The strip upon leaving the last of these sections passes through two enclosed cooling hoods about 16 feet in length and then into a water cooled cooling section approximately 11 feet long. While still protected by the special furnace atmosphere it is cooled to around 600° F. before it is brought out into the air. It will be understood that the dimensions of the furnace and its construction, as well as the speed of travel of the piece, and other factors, may, like the nature of the atmosphere, be considerably varied by the skilled worker in the art to obtain the desired result. The desired result is the formation of the thin, uniform, controlled and tightly adherent oxide film which we have described above.

Having produced this film in an annealing treatment, as explained above, we do not then pickle the strip, but we send it without further treatment to the cold rolls where it is further reduced. In our particular example the material which is given the oxide treatment is at a gage of .070. This material as so treated can be carried down by cold rolling without any further annealing treatments to as thin a gage as .015 inch or thinner. Similarly with a stock measuring .050 inch in thickness, and given our treatment, we can cold roll to .006 inch without intermediate annealing. With a treated material having a gage of say .031 inch we can go down to .005 inch without any difficulty and without intermediate annealing.

In this way it will be seen that, depending on the hot mill gage, we can go down to very light gages with only one intermediate annealing and with no intermediate pickling, at a very great saving in processing cost. Where it is impracticable to finish on the hot mill at lighter than say .140 inch, but where the finished gage is required to be as light as .005 inch, our procedure is to reduce on the cold mill as described to .070 inch, give the material our special annealing treatment, cold reduce it to say .030 inch, then pickle it, then give it another special annealing treatment without subsequent pickling, and finally reduce it to .005 inch without further heat treatments. In such a process we have two annealings and one pickling step in contrast to the 7 or 8 anneals and pickles which would ordinarily be required. Also it is possible in many instances to reanneal without pickling.

The final finishing steps, of course, both in the old procedure and in our new procedure, comprise a final anneal for softness, and then a temper roll if the customer requires this finish.

It will be noted from the description given above that we prefer to practice our special anneal (so called) as an intermediate between cold rollings. This is because the material when it is given our special anneal, should be characterized by a cold rolled rather than by a hot rolled surface. The best results are not secured, we find, by merely pickling the scale from a hot rolled strip or sheet and then giving it our special anneal preparatory to any cold rolling. It is possible, of course, to take hot rolled strip, thoroughly clean it by pickling, sand blasting or the like, and then give it a cold rolled surface by passing it one or more times through cold rolls without producing any very great reduction. Then it may be given our so called special anneal. In ordinary procedures, however, this would not produce as much saving as the routings described above; but it has its uses, especially in producing very light gages, and is not outside the scope of our invention.

The thin oxide film produced in our process need not be pickled away in instances where pickling would not otherwise be necessary. The reason for this is that the films respond to the usual commercial practices of abrasion polishing, and are not thick enough to have affected the essentially cold rolled character of the sheet surfaces. Thus the commercial practices of polishing may be practiced directly on our materials to produce finishes ranging from No. 4 to Nos. 7 or 8, without first removing the film.

Modifications may be made in our invention without departing from the spirit of it. Having thus described our invention, what we claim as new and desire to secure by Letters Patent is:

1. A process of producing stainless steel strip or sheet which comprises the steps of imparting to the cleaned surfaces of the metal a cold rolled finish, thereafter producing upon the said surfaces by a heat treatment a light-greenish coating of oxide not sufficient in thickness to destroy the cold rolled sheen of the surfaces and thereafter cold rolling the metal with a cold rolling reduction in excess of substantially 50%, while the surfaces of the metal are still covered with the said coating.

2. A process of producing stainless steel sheet or strip which comprises hot rolling the metal to intermediate gauge, pickling the metal, thereafter cold rolling it at least sufficiently to impart to its surfaces a cold rolled finish, then by a heat treatment, coating the surfaces of said metal with a uniform thin coating of oxide, greenish in color and not thick enough to obscure the cold rolled sheen of said surfaces, and without pickling, further cold rolling the metal.

3. A process as claimed in claim 2 in which the first cold rolling is a substantial reduction of the gauge of the metal but not exceeding 50%, in which the heat treatment for the production of the said coating is likewise an anneal for softening the metal, and in which the second mentioned cold rolling effects a reduction greater than substantially 50%.

4. A process of producing stainless steel sheet or strip which comprises hot rolling the metal to an intermediate gauge, annealing and pickling the metal, then reducing it substantially 50% by cold rolling, then annealing the metal so as to produce on its surfaces a controlled film of greenish oxide uniform in character and of such thinness as not to obscure the cold rolled sheen of the metal, and thereafter without pickling, cold rolling the material to a final gauge with a reduction of more than substantially 50%.

5. The process as claimed in claim 4 in which the gauge of the material after hot rolling is of the order of .140 inch, after the first cold rolling is of the order of .070 inch, and after the second cold rolling is of the order of .015 inch.

6. The process as claimed in claim 4 in which the gauge of the material after hot rolling is of the order of .140 inch, after the first cold rolling is of the order of .070 inch, and after the second cold rolling is of the order of .015 inch, and finally annealing and pickling the sheet or strip thus formed.

7. A process as set forth in claim 1 in which the heat treatment is an annealing in a controlled atmosphere.

8. The process as set forth in claim 1 in which the heat treatment is an annealing in an atmosphere of substantially pure nitrogen.

9. The process as set forth in claim 1 in which the heat treatment is an annealing in an atmosphere of substantially pure hydrogen.

10. A process as claimed in claim 1 in which the heat treatment is a continuous annealing at a temperature of the order of 1900 to 1950° F. in a controlled atmosphere.

11. A process of producing stainless steel sheet or strip which comprises hot rolling the metal to an intermediate gauge, annealing and pickling the metal, cold rolling it with approximately 50% reduction, heat treating the metal so as to form a uniform coating of greenish oxide on its surfaces of sufficient thinness to expose the cold rolled sheen of the metal, then without pickling, further cold rolling the material with a reduction of greater than substantially 50%, then pickling the material and again annealing it so as to produce upon its surfaces the same thin, uniform and controlled coating of oxide, and then again cold rolling the material with a reduction greater than substantially 50%.

12. A process of producing stainless steel sheet or strip comprising hot rolling the metal to an intermediate gauge, then annealing, pickling and cold rolling it to substantially the limit of practicable cold rolling reduction, then preparing the metal for further cold rolling reduction beyond said limit by annealing it under conditions to produce upon its surfaces a coating of oxide of uniform character and of the order of thickness of substantially 1/1000 inch, and thereafter cold rolling the material with a reduction greater than substantially 50%.

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