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PROCESS OF PRODUCING STAINLESS STEEL

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This invention relates to the process of producing chromium stainless steel for deep drawing purposes.

Chromium stainless steels having a chromium content of 15 to 22% are well-known in the art and in the industry as exemplified by Types 430 and 442 and others. Because of the current shortage of critical materials, such as nickel and the like employed in other types of stainless steel, the industry has attempted to utilize the chromium ferritic stainless steels containing from 15 to 22% chromium in deep drawing applications. Such attempts have not met with universal success because of the development of a condition called "roping" in such steels which is formed during the deep drawing operation and which it has been found to be substantially impossible to completely remove from the deep drawn article of chromium stainless steel.

In general, roping is a condition in which the surface of the chromium stainless steel in the strained areas becomes rippled with alternate, closely spaced ridges and valleys parallel to the direction of rolling when the steel is subjected to the drawing and forming operations. While it is not definitely known what causes roping, different theories have been advanced that it is caused by banding of carbides in the strip material or that it may result from preferred crystallographic orientation. Definite proof of the cause has not as yet been established.

This condition of roping has in the past been found to vary in degree from coil to coil of the chromium stainless steel strip from a given heat when such strip is subjected to identical drawing operations in the fabrication of utensils, hub caps and other articles of manufacture. It has heretofore been impossible from any known means of examination of the chromium stainless steel strip to determine the degree of roping which will develop after drawing the article. The serious nature of this problem which has faced the steel industry heretofore will be appreciated when it is realized that it was impossible to remove all evidence of such roping from the drawn article by any known polishing method and that it therefore was quite difficult and usually impossible to produce a highly polished finished product from the chromium ferritic stainless steel such as can be produced by using other types of stainless steel.

An object of this invention is to provide a process of producing chromium ferritic stainless steel that can be drawn without encountering roping in the surface in the strained areas.

Another object of this invention is to provide a process of producing chromium ferritic stainless steel strip for deep drawing purposes and in which the steel is subjected to a heat treatment to develop a temperature above about 1750° F. and up to about 2400° F. therein, depending on the composition, intermediate the final hot rolling and the following cold rolling treatment of the steel to thereby so condition the steel that the strip produced can be drawn without encountering banding in the surface of the strained areas.

Other objects of this invention will become apparent from the following description.

The steel to which this invention relates is that commonly known as chromium ferritic stainless steel having a chromium content of 15 to 22%, as for example:

Composition	Type 430, percent	Type 430F, percent	Type 442, percent
Cr	15-18	15-18	18-22
Ni maximum	.50	.50	.50
C maximum	.12	.12	.25
Mn maximum	1.00	1.25	1.00
Si maximum	1.00	1.00	1.00

the balance being substantially iron except in Type 430F, P, S or Se is present in not less than .07% nor more than .35% and Zr or Mo is present in up to .06% max. with the percent being by weight.

Heretofore, the general practice of producing strip from such chromium ferritic stainless steel has been to roll heated ingots of the steel on a blooming or slabbing mill into slabs. The slabs are then heated to a predetermined temperature and rolled to a predetermined hot roll gauge, preferably in a continuous hot rolling mill comprising roughing and finishing stands. In practice, such hot rolled strip will have a gauge of from .100 to .200 inches depending upon the following processing and the final thickness required in the strip.

It is common practice to then anneal the hot rolled strip, either in coil form or by continuously passing the strip through a suitable furnace to develop a temperature between 1450° F. and 1550° F. in the strip. If the annealing of the hot rolled strip is continuous, it has been found that the temperature of the furnace may be as high as 1700° F. and even up to 1750° F. but that the speed of the strip through such a continuous annealing furnace is such that the temperature of the steel strip does not exceed 1550° F., so that the actual temperature of the steel of the strip is below the critical temperature at which a phase change occurs. Such treatment will provide a soft material which can be cold rolled, the strip however usually being subjected to any of the well-known descaling treatments prior to cold rolling.

With the hot rolled strip thus treated, it is usually then subjected to a heavy cold rolling reduction followed by a final anneal and in some cases by a skin pass to develop a predetermined temper therein. Where the reduction required to work the hot roll strip to final gauge is quite large, the cold rolling reduction is often applied in two or more cold rolling steps with an intermediate anneal to develop a temperature of 1450° F. to 1550° F. in the metal being applied between such cold rolling steps.

The hot rolling and cold rolling steps and the final anneal and/or finishing steps for producing chromium ferritic stainless steel strip are well-known in the industry and need not be specifically described herein as the new steps of this invention are applicable to the known processes of producing the prior art chromium ferritic stainless steel strip. However, where the known processes produced strip which developed roping during drawing operations, when the steps of this invention are employed in conjunction with the known hot and cold rolling procedures, the resulting strip is free of roping when subjected to drawing operations.

While we have attempted to eliminate roping by varying the known hot rolling and cold rolling treatments, such variations have had little or no effect on the ultimate tendency of the chromium ferritic stainless steel strip so produced to rope during drawing operations such as are employed in producing cooking utensils, automotive parts and other articles of manufacture requiring a high finish for sanitary or decorative purposes.

We have, however, found that such tendency to rope during drawing operations can be eliminated by closely controlling the annealing temperature applied to the hot rolled strip of chromium ferritic stainless steel prior to the cold rolling of such strip.

Thus, instead of following the prior art practice of annealing the hot rolled strip to develop a temperature of 1450° F. to 1550° F. in the metal strip, in accordance with our invention the hot rolled strip is subjected to an anneal preferably in a protective atmosphere such as cracked ammonia, dry hydrogen or the like to develop a temperature above about 1750° F. and up to about 2400° F. in the metal of the strip. The high temperature anneal is preferably a box anneal of the hot rolled strip in coil form for a period of time sufficient to develop such high temperature in the metal strip. In practice, a time of from 5 minutes to 2 hours with the metal of the strip at temperature is usually sufficient. Preferably the annealing temperature developed in the hot rolled strip is maintained within the range of 1900° F. and 2150° F. as such an anneal is found to completely eliminate roping during drawing of the strip without being a detriment during the mill processing of the chromium ferritic stainless steel.

As an example of a typical but non-limiting mill processing of the chromium ferritic stainless steel including the novel features of this invention, reference may be had to the following schedule:

1. Heat the ingots to about 2350° F.
2. Roll into slabs about 3 inches thick.
3. Heat the slabs to about 2250° F.
4. Hot roll the slab into strip of from .100 to .200 inch thickness.
5. Box anneal the hot rolled strip in coil form in a protective atmosphere to develop a temperature above about 1750° F. and up to about 2400° F. in the metal of the strip, cooling the strip in the furnace.
6. Cold roll the annealed strip to effect a reduction of from 25 to 50%.
7. Anneal the strip in a protective atmosphere at a temperature of 1450° F. to 1550° F.
8. Cold roll to final gauge.
9. Final anneal in protective atmosphere of cold rolled strip at a temperature of 1450° F. to 1550° F.
10. Skin pass optional to develop temper.

When chromium ferritic stainless steel strip or sheet material is thus produced, it is capable of being deep drawn without developing roping. The high temperature anneal comprising step 5 of the foregoing schedule evidently has an effect on the structure of the metal, whether on the carbide distribution or on the grain orientation or on both is not certain, which so conditions the metal that when further processed by any of the known cold rolling and finishing techniques, the chromium ferritic stainless steel can be deep drawn without accompanying roping.

By practicing this invention, it is now possible to employ the chromium ferritic stainless steels in forming the different known deep drawn articles which require a high bright finish free from surface imperfections either for sanitary or decorative purposes. While the variation from the known processes appears to be slight, nevertheless, it is critical in eliminating roping during drawing while not causing too great a change in standard mill processing procedure.

We claim:

1. A process of producing chromium ferritic stainless steel for deep drawing purposes, said steel consisting of 15 to 22% chromium, not more than .50% nickel, not more than .25% carbon, not more than 1.25% manganese, not more than 1% silicon and the balance substantially all iron, including as steps an initial hot rolling of the steel followed by at least one cold rolling treatment, which process is characterized by the step of heating the hot rolled steel prior to cold rolling to develop a temperature above about 1900° F. and up to about 2150° F. therein, said processed chromium steel having the characteristic of being capable of being deep drawn without developing roping.

2. A process of producing chromium ferritic stainless steel for deep drawing purposes, said steel consisting of 15 to 22% chromium, not more than .50% nickel, not more than .25% carbon, not more than 1.25% manganese, not more than 1% silicon and the balance substantially all iron, including as steps an initial hot rolling of the steel followed by two cold rolling stages and an intermediate anneal, which process is characterized by the step of heating the hot rolled steel prior to cold rolling to develop a temperature above about 1750° F. and up to about 2400° F. therein, said processed chromium steel having the characteristic of being capable of being deep drawn without developing roping.

3. The process claimed in claim 2 in which said intermediate anneal is effective to develop a temperature between 1450° F. and 1500° F. in the steel being processed.

4. The process claimed in claim 2 in which said intermediate anneal is a continuous anneal of the partially processed steel in strip form to develop a temperature between 1450° F. and 1500° F. therein.

5. A process of producing chromium ferritic stainless steel, said steel consisting of 15 to 22% chromium, not more than .50% nickel, not more than .25% carbon, not more than 1.25% manganese, not more than 1% silicon and the balance substantially all iron, including as steps an initial hot rolling of the chromium steel followed by a cold rolling treatment, which process is characterized by the step of heating the hot rolled steel at a temperature above about 1750° F. and up to about 2400° F. prior to the cold rolling, said processed chromium steel having the characteristic of being capable of being deep drawn without developing roping.

6. A process of producing chromium ferritic stainless steel, said steel consisting of 15 to 18% chromium, not more than .50% nickel, not more than .12% carbon, not more than 1.25% manganese, not more than 1% silicon, from .07 to .35% of at least one element of the group consisting of phosphorous, sulphur and selenium, not more than .06% of at least one element of the group consisting of zirconium and molybdenum and the balance iron, including as steps an initial hot rolling of the chromium steel followed by a cold rolling treatment, which process is characterized by the step of heating the hot rolled steel at a temperature above about 1750° F. and up to about 2400° F. prior to the cold rolling, said processed chromium steel having the characteristic of being capable of being deep drawn without developing roping.

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