

UNITED STATES PATENT OFFICE

2,397,997

PROVIDING INHERENTLY AGING CHROMIUM-NICKEL STAINLESS STEEL WITH DIFFERENT TEMPERS

Ernest H. Wyche and Raymond Smith,
Pittsburgh, Pa.

No Drawing. Application June 21, 1944,
Serial No. 541,464

4 Claims. (Cl. 148—21.5)

This invention is a method of treating chromium-nickel stainless steel containing carbon and at least one of the stronger-than-chromium carbide formers, such as titanium, columbium, tantalum, etc., with its components that are ferrite formers proportioned to those that are austenite formers to cause the production of stress-laden ferrite at low temperatures when the steel cools to room temperature from temperatures where it is completely austenitic. Usually the steel contains aluminum.

As disclosed and claimed in the Wyche and Smith application, filed October 8, 1941, Serial No. 414,194, of which this application is a continuation-in-part, the stress-laden ferrite, of such a steel, is inherently aging, by heating above room temperature, to a higher hardness and strength. By varying the proportion between the ferrite formers and the austenite formers the steel may be made to contain more or less of this aging ferrite, with the balance austenite, but this means of controlling its response to aging has certain undesirable features.

Normally, the steel is made to contain as much of the stress-laden ferrite as possible. This is desirable for obvious reasons. At the same time, however, it is desirable to provide the user of the steel with steel of different tempers, since a steel that ages to maximum hardness and strength may not have adequate ductility for certain applications, or, in other words, may be of too high a temper. That is to say, different applications require a steel that can be aged to different hardnesses and strengths, with the attendant differences in ductility, it being understood that these properties are incompatible in the sense that maximum hardness and strength has minimum ductility, whereas maximum ductility attends minimum hardness and strength. Since the stress-laden ferrite hardens and strengthens through the aging phenomena, it may be underaged or overaged to lower hardness and strength with attendant greater ductility as compared to the ductility obtained by aging to maximum hardness and strength. However, there are limits to the properties that can be obtained by varying the aging treatment, such limitations being inherent to assemblies including parts where maximum strength and hardness is desired regardless of ductility loss and parts where greater ductility is desired even though hardness and strength must be sacrificed to attain this ductility.

The present invention provides a means for providing steel of the type described with different tempers in the sense that when steel of the different tempers is subjected to exactly the same aging treatment, different hardnesses and strengths result with attendant different ductility values.

With the foregoing in mind, the present invention comprises heating the described steel containing the stress-laden ferrite to temperatures just above its austenitizing temperatures to produce the lowest temper, to temperatures considerably higher to produce the highest temper and to intermediate temperatures to produce an intermediate temper, the time at which the steel is maintained at temperature being relatively unimportant excepting that the steel must be brought to the temperature selected, this heating being followed by cooling to produce the stress-laden, inherently aging ferrite. Thereafter, the same aging treatment will age the different tempers to different hardness, strength and ductility, the lowest temper having the lowest hardness and strength with the most ductility and the highest temper having the highest hardness and strength with the lowest ductility, while the intermediate tempers will age to intermediate values.

More specifically, the described steel is preferably produced with a composition comprising from .05 to .08% carbon, from 15 to 18% chromium, from 4 to 7% nickel, .2% plus 5 to 12 times the carbon content titanium, from .03 to 1% aluminum and manganese about .50% for 7% nickel or 1 to 2.5% for 5% nickel or 3 to 6% for 3% nickel, with the balance mainly iron. This represents the steel as it is commercially made, titanium being more readily available in this country than the other stronger-than-chromium carbide formers. With steel of this general analysis, three tempers provide a practicable commercial temper range. Of these, the lowest results when the steel containing the stress-laden ferrite is heated to about 1300° F. and is then cooled to reproduce the stress-laden ferrite, an intermediate temper results from heating it to 1400° F. and cooling as described, while a high temper results from heating it to 1600° F. and cooling to produce the described ferrite, these temperatures varying somewhat with the composition.

In the case of a specific example of the steel containing .07% carbon, .60% manganese, 7% nickel, 17% chromium, .60% titanium, .20% aluminum, and with the balance mainly iron, the various treatments provided the following results in the case of hot rolled sheet:

	Pounds per square inch	Per cent yield strength	Pounds per square inch tensile strength	Per cent elongation
HR+1300° F.+950° F. 1/2 hr.	133,000	.2	158,000	16
HR+1400° F.+950° F. 1/2 hr.	165,000	.2	177,000	12.5
HR+1600° F.+950° F. 1/2 hr.	187,000	.2	193,000	8.5

The above values represent tension tests taken transverse to the rolling direction, but directional yield strengths in both tension and compression for a given heat treatment are very nearly the same, as contrasted to what is to be observed in the case of ordinary austenitic stainless steel strengthened by cold work alone. It is to be understood that the 950° F. heating for one-half hour represents the aging treatment which, it will be noted, is the same in all instances although producing different strengths and ductilities as represented by tensile strength and elongation values. As previously mentioned, the time of the austenitizing treatment producing the different tempers is not too important, but it should be consistent with good heat treating practice, 15 to 30 minutes for sheet material of 18 gauge or thinner being adequate, for example. Furthermore, if the steel to which the temper imparting treatment is applied has been excessively cold worked, it is necessary to anneal it at a high enough temperature to remove the cold-work strain, this being followed by cooling to produce the stress-laden ferrite to permit application of the temper adjusting heat treatment. Cold work up to a 20% reduction in the thickness of sheet does not usually require this preliminary anneal, and greater amounts of cold reduction may be tolerated if the anneal providing the various tempers is high enough in temperature. The different tempers also have different properties in their unaged condition, what are considered the lower tempers in the aged condition being harder and the higher aged tempers being softer prior to aging. That is to say, the austenitizing temperature producing the lowest aged temper gives the highest unaged temper and that which gives the highest aged temper provides the lowest unaged temper. The intermediate aged temper is attended by an intermediate unaged temper.

The heat treatment providing the different temper functions as a solution anneal. When this solution anneal is relatively low in temperature, the following cooling to produce the stress-laden ferrite results in the steel having a microscopically visible structure exhibiting a lamellar constituent. With the higher solution anneals providing the higher tempers there is less of this lamellar constituent microscopically visible in the steel structure. Therefore, microscopic examination of the steel may serve as a fair indication of its probable temper, large amounts of the lamellar constituent indicating a low temper and relatively small or no visible amounts of the lamellar constituent indicating a high temper.

Apparently there is at least some increase in temper with each increase in the temperature of the solution anneal, but temperatures much above 1600° F., for instance, result in excessive scaling and warping, and, in any event, produce such a high temper that the steel, when properly aged, has too little ductility for some applications.

We claim:

1. A method of controlling the temper of chromium-nickel stainless steel containing carbon and

at least one of the stronger-than-chromium carbide formers such as titanium, columbium, tantalum, etc., with its components other than said carbide formers that are ferrite formers proportioned to those that are austenite formers to cause the production of stress-laden ferrite with any remainder austenite at low temperatures when the steel cools to room temperatures from an austenitizing temperature, said method comprising heating the steel to temperatures just above said austenitizing temperatures to produce the highest unaged and lowest aged temper, to temperatures considerably higher to produce the lowest unaged and highest aged temper, and to intermediate temperatures to produce an intermediate temper, followed by cooling to produce said ferrite.

2. A method of controlling the temper of age hardening steel containing from .05 to .08% carbon, from 15 to 18% chromium, from 4 to 7% nickel, .2% plus 5 to 12 times the carbon content titanium, from .03 to 1% aluminum and manganese about .50% for 7% nickel or 1 to 2.5% for 5% nickel or 3 to 6% for 3% nickel, with the balance mainly iron; said method comprising heating the steel to about 1300° F. to give it a higher unaged and lower aged temper, to about 1400° F. to give it a medium temper and to about 1600° F. to give it a lower unaged and higher aged temper, followed by cooling the steel to provide it with a stress-laden ferritic structure rendering it age hardening.

3. A method of controlling the temper of age hardening steel containing about .07% carbon, 60% manganese, 7% nickel, 17% chromium, .60% titanium, .20% aluminum, and with the balance mainly iron; said method comprising heating the steel to about 1300° F. to give it a higher unaged and lower aged temper, to about 1400° F. to give it a medium temper and to about 1600° F. to give it a lower unaged and higher aged temper, followed by cooling the steel to provide it with a stress-laden ferritic structure rendering it age hardening.

4. A method of controlling the temper of chromium-nickel stainless steel containing carbon and at least one of the stronger-than-chromium carbide formers such as titanium, columbium, tantalum, etc., with its components other than said carbide formers that are ferrite formers proportioned to those that are austenite formers to cause the production of stress-laden ferrite with any remainder austenite at low temperatures when the steel cools to room temperatures from an austenitizing temperature for the structure producing said ferrite, said method comprising heating the steel to temperatures just above said austenitizing temperatures to produce the lowest aged temper, to temperatures considerably higher to produce the highest aged temper and to intermediate temperatures to produce an intermediate temper, followed by cooling to produce said ferrite, the steel being thereafter artificially aged by heating.

ERNEST H. WYCHE.
RAYMOND SMITH.