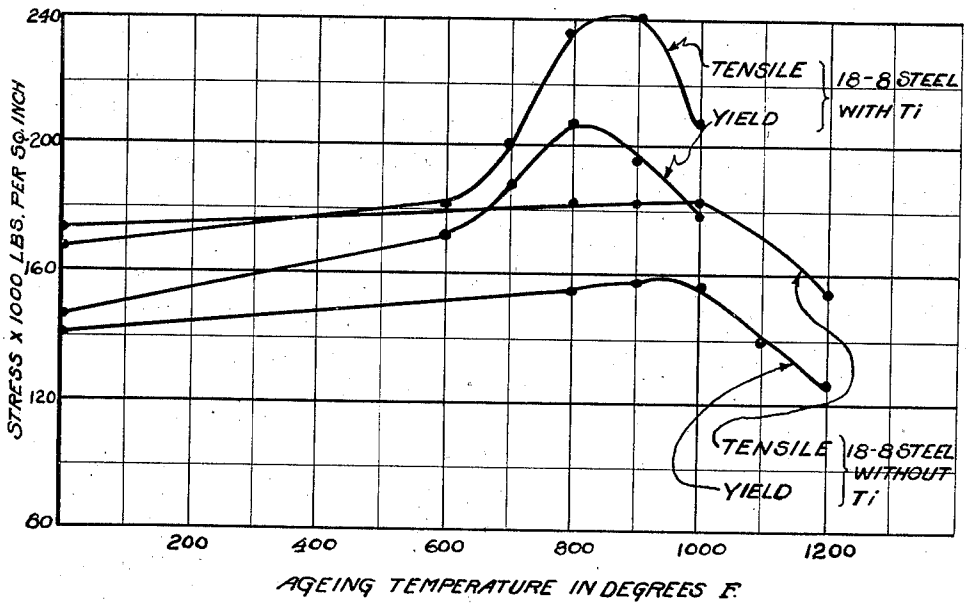
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PROCESS FOR IMPROVING THE PHYSICAL PROPERTIES OF AUSTENITIC STEELS

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PROCESS FOR IMPROVING THE PHYSICAL PROPERTIES OF AUSTENITIC STEELS

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This invention relates to the improving of the physical properties of corrosion-resisting steels.

Heretofore titanium has been included as a true alloying element in heat-resisting austenitic steels of high alloy content, but it has not been found possible to retain in such alloy steels the resistance to corrosion which the same alloy steels possess without the titanium content and at the same time impart suitable physical properties. For a number of uses, it has not heretofore been necessary to improve upon the physical properties of these corrosion-resisting alloy steels of the prior art. However, for other purposes, these same alloy steels, because of their poor physical properties, or, if their physical properties have been sufficiently improved, because of their decreased resistance to corrosion, have not been regarded as practicable.

That these steels have not in the past been capable of being subjected to the known age-hardening processes and still retain their corrosion-resisting properties is one of the reasons why they have not found more uses in industry. As disclosed in papers by W. Kroll (Wissenschaftliche Veroeffentlichungen des Siemens-Konzerns, v. 8, 1929, pp. 220–35; Metallwirtschaft, v. 9, 1930, pp. 1043–45) and by R. Wasmuht (Arch. f. Eisenh., v. 5, pp. 45–56 and 261–66), titanium may be introduced into such alloy steels to give the useful age-hardening effects, but in every case it has been necessary to employ so much titanium that the corrosion-resisting properties have been lost, thus rendering the steels no longer resistant to corrosion and, if a full age-hardening treatment is given, much too coarse and brittle.

It is, therefore, an object of this invention to provide a process for successfully treating titanium-containing austenitic steels to the end that they may be enabled to retain the resistance to corrosion which the same steels, without the introduction of titanium, are known to possess, and yet have physical properties better than those heretofore attained. Such steels which contain no titanium are resistant to corrosion only if they have been heated to a temperature above the recrystallization temperature so that substantially all the carbides will be in solution, and then quickly cooled. This invention relates to the treatment of titanium-containing austenitic steels in which substantially all the carbides are present in solution at normal temperatures.

Another object is to provide an improved corrosion-resisting steel which is sufficiently strong to make possible its use where strength and resistance to corrosion are needed; for example, in the structure of heavier- and lighter-than-air craft.

The invention resides in part in the successful artificial age-hardening of austenitic steels containing titanium in an amount which, while appreciable, is not so great as to affect their corrosion-resisting qualities. More particularly, it resides in the discovery that by strain-hardening a titanium-containing austenitic steel and then subjecting it to a precipitation heat treatment at elevated temperatures up to approximately 1200° F., there is obtained a product which is corrosion-resisting and yet has greatly improved physical properties. The values of the physical properties obtained will vary somewhat depending upon the analysis of the steel, the degree of strain-hardening, the temperature of the precipitation heat treatment, and the time the steel is retained at the elevated temperature; but the improvement of the physical properties will in every case be much greater than the mere effects of the strain-hardening step or of the heat treatment step following strain-hardening but without the addition to the alloy of the titanium.

The benefits derived from the heat treatment following strain-hardening will vary with the amount of strain-hardening to which the steel is subjected. For instance, a steel analyzing 18.0% of chromium, 8.0% nickel, 0.05% carbon and 0.40% titanium, when strain-hardened from a tensile strength of 90,000 lbs./sq. in., its original annealed state, to a tensile of 140,000 lbs./sq. in., was found to increase on subsequent heat treatment to a tensile of 200,000 lbs./sq. in. The same steel when strain-hardened to a tensile of 165,000 lbs./sq. in. is strengthened to a tensile of 240,000 lbs./sq. in. by the heat treatment herein described.

As a general rule, the preferred temperature of the precipitation heat treatment step will be found to be between 600° and 1200° F., the best results having been obtained when employing a temperature in the neighborhood of 900° F. It is believed that the so-called precipitation heat treatment step causes the precipitation of microscopic or sub-microscopic particles of titanium carbide; also, that the practice of this invention gives rise to a steel which has no internal stresses after the steel has been heat-treated to increase its physical properties. While merely heating the steel to a temperature of between 600° and 1200° F. and at once cooling it gives an improvement in the physical properties, an even greater improvement is obtained by retaining it in this temperature range for a period of approximately an hour. The

time may be extended, but generally it will be found that there is no further increase in physical properties, even though the steel is maintained at the desired elevated temperature for a period of as long as 24 hours. Heat treatment for a period of a half hour gives greatly improved properties, but apparently treatment for an hour gives the optimum improvement.

Although any austenitic steel with the inclusion of titanium may be employed in the practice of the invention, the austenitic chrome-nickel steels, such, for example as those having chromium and nickel contents of approximately 18% and 8%, respectively, and those having chromium and nickel contents of approximately 25% and 12%, respectively, have been found particularly valuable. The steels preferred in the practice of this invention should, in general, contain not more than approximately 0.20% of carbon and sufficient titanium to bring about the desired properties by precipitation, which is usually found to be in an amount of approximately five times that of the amount of carbon employed. However, titanium contents in the steel below five times the carbon content have also a marked increase in properties of the steel upon heat treatment. It is also found that with more than 1% of titanium, the corrosion resistance of the steel is lessened somewhat. The other ingredients usually found in steels of this type, such as sulfur, phosphorus, manganese and silicon, may be varied at will. Thus, the amounts of each may be, respectively, not more than approximately 0.03%, 0.03%, 0.70% and 0.50%, as is the standard practice of the steel maker's art.

Illustrative of the invention is the following test carried out with a heat of alloy steel of the following approximate analysis, commonly known without the inclusion of the titanium as (18—8) or (KA2S) alloy steel:

	Percent
Chromium	18
Nickel	8
Carbon	0.05
Titanium	0.40
Other ingredients	As above

This steel, having a maximum tensile strength in its original annealed state of 90,000 lbs./sq. in., was strain-hardened to an approximately 40 per cent reduction in draft, its tensile strength being 165,000 lbs./sq. in. It was then subjected to a temperature of approximately 920° F. for a period of an hour, after which it was quenched in water. It is to be understood that the step of quenching in a liquid is not necessary, but that the steel may be cooled off slowly in the air with equally successful results.

After this treatment it was found that the modulus of elasticity had recovered from 23,700,000 to 26,600,000, an increase of about 12%. The tensile strength was raised from 165,000 lbs. per square inch as strain-hardened to 240,000 lbs. per square inch, an increase of approximately 45%. The yield point (0.1%) was also raised from 145,000 lbs. per square inch to 200,000 lbs. per square inch, an increase of approximately 38%. An increase in hardness was also noted, a Rockwell hardness of "A" 69.5 to "A" 70 (60 kg.-Brale load with diamond penetrator) being increased to "A" 75. The elongation was found to have decreased slightly, but not to an excessive extent. Moreover, in addition to all these improved properties, the steel retained to a marked degree the characteristic resistance to corrosion of the austenitic chrome-nickel steels.

The results of these tests are shown in accompanying drawing, where the tensile strength and yield point of this (18—8) steel are plotted against ageing or tempering temperature. It is observed that the optimum increase is obtained at a temperature of about 900° F. Also shown in the drawing are the results obtained by subjecting to similar treatment the same (18—8) steel but not containing the titanium. It is noted that only a slight increase in tensile and yield are obtained up to 1000° F., clearly demonstrating the effects of titanium and the process of this invention.

It is to be understood that the invention is not limited to the two steps of strain-hardening and heat-treating, but extends to numerous variations of these steps. Thus, one alternative procedure is to strain-harden the steel to a lesser degree, heat-treat it and then repeat the strain-hardening step. Also, it may be desirable, in some instances, to include a large number of steps of strain-hardening followed by heat treating. It will be understood that any of the known methods of strain-hardening may be employed in the practice of the invention. It will further be understood that the precipitation heat treatment may be followed by any method of cooling. Also, any titanium austenitic steel may be improved by the practice of the process, examples other than chrome-nickel austenitic steels being the nickel-manganese austenitic steels.

It is readily apparent that the products of this invention have greatly improved properties, making possible the employment of corrosion-resisting steels in many new ways. Thus, the alloy steels of this invention by virtue of their resistance to corrosion and their great strength may be used in place of the present alloys used in the aircraft industry, both heavier-than- and lighter-than-air. The alloy steels of this invention are so much stronger than duralumin, for instance, that by employing a sufficient amount to give the same tensile strength as given by duralumin, an even smaller weight may be employed even though the specific gravity of the steel is higher than that of duralumin. Being in addition resistant to corrosion, the steels of this invention will thus find use wherever the two qualities of great strength and corrosion-resistance are required.

Although only the preferred form of the invention has been illustrated and described in detail, it will be apparent to those skilled in the art that the invention is not so limited but that various modifications may be made therein without departing from the spirit of the invention or from the scope of the appended claims. It is intended that patent shall cover, by suitable expression in the appended claims, whatever features of patentable novelty reside in the invention herein disclosed.

What is claimed is:

1. The process of improving the physical properties of a chromium-nickel austenitic steel containing a small amount of titanium which steel has been quenched from a temperature above the solution temperature to a normal temperature, which comprises the steps of improving the tensile strength of the steel by cold-working and thereafter re-heating below recrystallization temperature but at such a temperature as to obtain a critical dispersion of carbide therein.

2. The process of improving the physical prop-

erties of a chromium-nickel austenitic steel containing a small amount of titanium which has been quenched from a temperature above the solution temperature to a normal temperature which comprises the steps of improving the tensile strength of the steel by cold-working and thereafter re-heating to a temperature between 600 and 1200° F. to obtain a critical dispersion of carbide therein.

3. The process of improving the physical properties of a titanium-containing chromium-nickel austenitic steel which comprises the steps of improving the strength of the steel by cold-working and then re-heating below recrystallization temperature but at such a temperature as to obtain a critical dispersion of carbide therein.

4. The process of improving the physical properties of an austenitic steel containing approximately 18% chromium, 8% nickel, less than 0.07% carbon and 0.20 to 1.00% titanium which has been quenched from a temperature above the solution temperature which comprises the steps of improving the tensile strength of the steel by cold working and thereafter heating to a temperature of approximately 600° to 1200° F. to obtain a critical dispersion of carbide therein.

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