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HARDENABLE STAINLESS STEEL

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1 Claim. (Cl. 75—124)

This invention is an improvement in hardenable stainless steels having the components thereof balanced to produce a structure that at least partly transforms to alpha ferrite upon cooling and more particularly is an improvement over the hardenable stainless steel disclosed in the Wyche and Smith Patent No. 2,381,416.

Industrial experience in making and fabricating this steel has demonstrated its many advantages as a structural material. However, this steel is subject to the formation of segregations of non-metallic nature. These segregations have a deleterious effect on both the surface and the forming properties of the steel, particularly when used in sheet form and have prevented its use for some applications.

Non-metallic segregations or inclusions found in this steel appear to be constituted of an agglomeration of titanium nitrides and titanium cyanonitrides as the principal ingredients, with smaller quantities of alumina apparently produced by the deoxidation reactions. These segregations are easily distinguishable with the naked eye on freshly machined or on polished surfaces, appearing as black stringers on grey surface of steel.

While these stringers or inclusions can be largely overcome by substituting about 1.50% columbium for the .75% titanium used in commercial heats of this steel, the columbium-bearing steel does not develop the desired hardness on aging and, moreover, columbium is much more expensive and subject to strict governmental control.

The present invention accordingly has for its object, providing steel of the above class substantially free from non-metallic segregations or stringers and having the desired aging characteristics.

Extensive experimental investigation directed towards the explanation of this lack of response to the hardening treatment in columbium-bearing steel lead to the discovery that columbium forms an intermetallic compound with iron, and this compound is much less active as a hardening agent than columbium simply dissolved in iron. It has been found, furthermore, that the percentage of columbium bound as this intermetallic compound varies as a function of columbium concentration in steel, and the function involved is not a straight-line relation.

Experiments have shown a sharp break in the ratio between columbium bound in an intermetallic compound, the exact nature of which is not perfectly understood at present, and the total columbium contained in the alloy.

The evidence obtained shows that in amounts less than 0.50% total columbium, very little intermetallic compound is formed, while above this content the amount of intermetallic compound increases rapidly. A number of experiments have shown that in every steel of the above composition which contains a sufficiency of columbium, there is a critical point at about 0.50% columbium at which the ratio between bound and dissolved columbium shows a definite break.

It has further been determined that objectionable non-metallic inclusions or stringers can be prevented by maintaining the titanium content below about .50% and substantially completely eliminated by maintaining the titanium below .25%. Following this, I have shown that steel having the desired hardening characteristics and containing .03 to .15% carbon, 12 to 20% chromium, 2 to 20% nickel, .25 to 10% manganese, up to 1.00% aluminum, preferably .08% maximum carbon, 6.25 to 7.50% nickel and 16.00 to 17.50% chromium can be made substantially free from non-metallic inclusions by alloying carbide formers therewith as follows, i. e., between .25 to .50% titanium and .50 to 1.00% columbium. If substantially complete freedom from non-metallic inclusions of the nitrides and cyanonitrides is desired about .25% titanium and 1.00% columbium should be used. The ferrite forming elements should of course be proportioned to the austenite formers so that steels alloyed as described above and thermally treated in a manner recited in United States Patents Nos. 2,381,416 and 2,397,997 to Wyche and Smith fully respond to the hardening treatment.

Proportioning columbium in this manner offers several collateral advantages. The practice permits useful utilization of substantially 75% of columbium added as compared with 25% utilization associated with the addition of 2% of this element. Lower titanium and columbium concentrations reflect themselves in a lower expense for the metals. Since the recovery of additional elements is less erratic with smaller percentages of these additions, a more accurate control of the composition is assured. A closer compositional control reflects itself in a reduced percentage of rejected heats.

I claim:

A stainless steel hardenable by heat treatment containing .03 to .15% carbon, 12 to 20% chromium, 2 to 20% nickel, .25 to 10% manganese, up to 1.00% aluminum, about .25% titanum and about 1.00% columbium, with the balance iron and residual impurities and having a structure that partially transforms to alpha ferrite on cooling, said steel being characterized by substantial freedom from non-metallic nitride and cyanonitride inclusions.

References Cited in the file of this patent

UNITED STATES PATENTS

2,381,416	Wyche et al.	Aug. 7, 1945
2,416,515	Evans	Feb. 25, 1943
2,447,897	Clarke, Jr.	Aug. 24, 1948

OTHER REFERENCES

American Society for Metals, Preprint No. 5, 1946, page 11.