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AUSTENITIC ALLOY STEEL

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2 Claims. (Cl. 75—126)

The invention relates to corrosion resistant austenitic chromium-manganese alloy steels and to articles made therefrom, and has for its primary object the improvement of the characteristics of such steels.

Steels containing about 12% to 25% chromium, 6% to 14% manganese, a minor part of the manganese being replaceable by nickel, and carbon in an amount not exceeding about 0.2%, are corrosion resistant, tough and ductile. Such steels normally consist of austenite or of a mixture of austenite and a ferritic constituent, the proportion of austenite being largely dependent on the ratio of chromium to austenite-promoting elements in the steel and also on the rate at which the steel has been cooled from elevated temperatures above its upper critical temperature (about 950° C.). The corrosion resistance, toughness, and ductility of these steels are usually greatest when their structure is most nearly completely austenitic and the proportions of chromium and austenite-promoting elements should therefore be carefully selected in order to ensure a steel having the maximum proportion of austenite. On the other hand, the austenite so produced is relatively unstable and the resultant steels are difficult to hot work and to heat treat successfully.

During hot working, these steels have a tendency to tear, check or crack, apparently because of the partial decomposition of the austenite under the conditions of high temperature and mechanical work, forming a small amount of an undesirable ferritic constituent throughout the austenite matrix. This small proportion of ferritic constituent formed during hot working appears to have a serious detrimental effect on the hot working characteristics of steels of the class in question.

Measures relying for their beneficial effect on the production of a stable austenite have been proposed to improve the hot workability and heat treating characteristics of the foregoing steels, but none has been entirely satisfactory. One proposal has been to increase the carbon content and thus, by promoting a more stable austenite, to restrict the decomposition of that constituent. This expedient, while improving the hot workability and heat treating characteristics of the steel, has a deleterious effect on the corrosion resisting properties of the metal and is of little or no value. It has also been proposed to promote a more stable austenite by increasing the manganese content or combined nickel and manganese contents of the steel, but this expedient is only partially effective and is moreover, relatively expensive. The use of a very high proportion of nickel has the added disadvantage of increasing the hot-stiffness of the metal, thereby increasing the difficulty of hot working it.

We have found that the addition of relatively small amounts of nitrogen to steels containing about 12% to 25% chromium, 6% to 14% of an austenite-promoting element of the group consisting of manganese and mixtures of manganese and nickel wherein the percentage of manganese is greater than that of the nickel; and carbon in an amount less than 0.20%, and preferably less than 0.12%, considerably improves the hot working, heat treating, and other characteristics of such steels without impairing their excellent corrosion resisting and physical properties or without substantially increasing their resistance to deformation at hot working temperatures. The nitrogen content is uniformly distributed throughout the steel and should be in an amount at least 0.05% but not exceeding 0.5%. As is customary in steels of this class, copper may be added in amounts up to about 2.5%, and one or more elements of the group consisting of aluminum and silicon may be present in an amount not exceeding 3% and preferably not exceeding 1%. The percentage of nitrogen that can be held in stable combination in these alloys depend on their chromium and manganese contents. If the chromium content is about 25% and the manganese content is high, the nitrogen content may rise to 0.5%, but when the chromium and manganese contents are lower, it is advisable to keep the nitrogen content below 0.2%, and usually below 0.15%.

We have observed that the nitrogen imparts stability to the austenitic constituent of the steel, strengthens and otherwise improves the properties of the ferritic constituents, particularly at elevated temperatures, and promotes a fine-grained structure throughout the steel. It is probable that these effects are responsible, at least in large part, for the improved hot workability of the steels, and for the fact that the cooling rate necessary, for a given section, to retain a very high proportion of austenite, can be slower than that necessary to retain the same proportion of austenite in a steel containing little or no nitrogen but otherwise of similar analysis. The reduced cooling rate is particularly valuable in imparting good ductility and toughness to articles which have been fabricated by welding, and to those articles, either cast or wrought, which, owing to their shape, thickness or other

factors, could not be very rapidly cooled by known practical methods.

Other valuable characteristics resulting from the addition of nitrogen to the steels herein described are that the yield point, maximum strength, and impact strength of the hot-worked steels tested at room temperature are at least as good as those properties of nitrogen-free steels of otherwise similar analysis, while their ductility is substantially increased.

Improvements in the physical properties of the hot-worked steels are indicated in the table which gives the results of tests made on representative samples of steels of the class in question, with and without additions of nitrogen.

Table

Number	Composition (remainder Fe)						Tensile test results					
	%Cr	%Mn	%Ni	%C	%Cu	%N	Y. P.	M. S.	%EL	%RA	Izod	B. H.
1	18.8	8.9	None	0.09	None	0.03	59	109	38	54	120	196
2	18.5	8.8	None	0.10	None	0.12	61	123	54	57	120	201
3	19.2	8.9	None	0.11	0.7	0.04	61	98	43	63	118	187
4	18.6	8.7	None	0.09	0.9	0.14	62	101	48	63	120	201
5	18.6	6.3	2.2	0.07	None	0.03	54	128	42	52	119	187
6	18.6	6.7	2.2	0.09	None	0.10	57	124	53	59	119	192
7	18.8	8.9	None	0.09	None	0.03	57	107	36	49	68	187
8	18.5	8.8	None	0.10	None	0.12	58	114	53	66	127	207
9	19.2	8.9	None	0.11	0.7	0.04	57	107	47	52	44	187
10	18.6	8.7	None	0.09	0.9	0.14	56	102	53	73	120	192
11	18.6	6.3	2.2	0.07	None	0.03	51	126	42	53	119	187
12	18.6	6.7	2.2	0.09	None	0.10	49	123	54	56	119	187

NOTE.—Steels No. 1 to 6 hot worked and water quenched from about 1050° C. before testing.
Steels No. 7 to 12 hot worked and air cooled from about 1050° C. before testing.

In the above table, the following symbols are used: Y. P. for yield point in thousands of pounds per square inch; M. S. for maximum stress in thousands of pounds per square inch; %EL for percentage elongation; %RA for percentage reduction in area of cross-section accompanying the elongation; Izod to designate the Izod impact resistance in foot pounds; B. H. for the hardness values on the Brinell scale. The tensile tests were made on standard 0.505 in. diameter tensile test samples as specified by the American Society for Testing Materials.

The nitrogen addition is also beneficial in improving the physical characteristics of the cold-rolled chromium-manganese steels. The steels of the invention can be more severely cold worked than nitrogen-free steels of similar analysis without inducing an undesirable degree of brittleness in the material. This characteristic is of particular importance in articles which have been fabricated by deep drawing inasmuch as the residual stresses ordinarily present in such articles are thus appreciably reduced and a greater degree of permanency in the finished article is ensured. Another valuable characteristic of these steels is that they may be cold worked to give a material of high yield strength without deleteriously affecting their ductility and toughness. It is believed that this benefit is due largely to the stabilizing effect of nitrogen on the austenite of the steel inasmuch as magnetic tests show that after a given degree of cold work has been imparted to steels of the invention and to nitrogen-free steels of otherwise similar analysis, the nitrogen-free steels are considerably more magnetic than those of the invention.

While we have disclosed several specific embodiments of our invention, it is evident that such embodiments are by way of example, and may be modified within the scope of the invention as defined in the appended claims.

We claim:

1. Austenitic alloy steel containing between 12% and 25% chromium; between 6% and 14% manganese; carbon in an amount not over 0.2%; 0.05% to 0.5% nitrogen; remainder iron.

2. A steel article hot worked under conditions that promote the formation of a ferritic constituent and subsequently quenched from above the upper critical temperature (about 950° C.) and composed of a steel as defined in claim 1.

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