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CORROSION RESISTANT STEEL ALLOY

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4 Claims. (Cl. 75—126)

The invention relates to corrosion-resistant chromium alloy ferritic steels, and to articles composed of such steels and has for its primary object an improvement in the resistance of such steels to certain types of corrosion.

Corrosion-resistant ferritic steels containing 15% to 35% chromium are extensively used in contact with media that rapidly corrode ordinary iron and steel. Despite the excellent resistance of known chromium steel to uniform general corrosion over the surface of the metal, undesirable deterioration and failure sometimes occur from a local attack which produces holes or depressed areas. Such local attack renders an article useless long before general deterioration or consumption has occurred.

Two types of localized attack have been observed, the effects of which are readily distinguishable although their ultimate causes may be similar. One is characterized by the formation of holes and pits of relatively small diameter at points over the entire surface of the metal subject to corrosion and this is usually called "pitting". The other is "contact corrosion" which occurs only at and adjacent to an area of imperfect contact of some object with the corrosion-resistant metal surface. The object may be of any material, such as a piece of dirt, oil, rust, glass, wood, or even chromium steel. Contact corrosion does not ordinarily proceed over the entire surface of the metal but the diameters of the corroded spots are considerably larger than those of the holes produced by pitting.

Although localized attack may occur by the action of any of numerous media, trouble of a particularly serious nature is caused by aqueous saline solutions, especially saline solutions having a pH less than seven.

Attempts have been made to overcome localized attack of the type herein described, one of which has been to lower the chromium content to a point where general corrosion proceeds at a moderate rate, but such expedients make the metal less resistant to contact corrosion, do not eliminate pitting, and adversely affect the physical properties of the alloy.

I have tested the effect of a great many alloying elements on the resistance of the chromium ferritic steels to localized corrosion. Nearly all of those tested have no substantial beneficial effect. However, certain combinations of alloying elements in relatively small proportions were found to improve resistance to this form of corrosion to a surprisingly great extent. Specifically, molybdenum strongly inhibits pitting and to some extent retards contact corrosion and, although columbium has no substantial inhibiting effect on either form of attack, mixtures of molybdenum and columbium greatly improve the resistance of the steels to both types of localized corrosion. The data appearing in the following table indicate the improvement imparted by these additions. These data were obtained by completely immersing polished samples in an aqueous solution containing 10% sodium chloride and 5% ferric chloride. The solution was contained in glass beakers and each sample rested on the bottom of a beaker. The test is an accelerated one, and the total time of immersion was two hours.

Composition (rest substantially iron)

Steel	Cr	C	Cb	Mo	Results of tests
	Percent	*Percent*	*Percent*	*Percent*	
1	17	0.11	None	None	Numerous pits.
2	18	0.08	None	5.63	A few pits.
3	18.5	0.10	0.90	3.08	Nearly unaffected.
4	27	0.15	None	None	Numerous pits.
5	25	0.10	None	3.37	A few small pits.
6	22	0.24	1.17	3.13	No pits.
7	23	0.11	1.24	3.09	Do.
8	23.5	0.16	2.17	3.30	Do.
9	26	0.10	1.05	4.16	Do.

Other experiments made in calcium hypochlorite solutions and other saline solutions have corroborated the results of the ferric chloride tests, showing definitely that by adding molybdenum and columbium to the plain high chromium steels in certain critical proportions a marked improvement in resistance to corrosive attack is obtained. Further corroboration has been secured from long-time tests.

The invention comprises an alloy ferritic steel, and articles composed of such steel, which in normal use are subjected to corrosive conditions which tend to produce localized corrosive attack in high chromium steels, containing 15% to 35% chromium, carbon in an amount not exceeding 0.35%, and effective amounts of molybdenum and columbium serving to inhibit the localized corrosive attack. The molybdenum is suitably in an amount of about 1% to 5% of the steel, and the columbium should be in an amount at least four times the carbon content, but not exceeding ten times the carbon content by more than 1.5%. Preferably, about 0.5% to 3% manganese is included in the steel to improve its forgeability and other hot working characteristics. Nitrogen in an amount not exceeding 0.5% may be added to improve the ductility and tough-

ness or other properties of the steel, but the nitrogen need not ordinarily exceed 0.3%. Silicon or aluminum, or both, may also be included in the steel according to the present invention; but it is preferable that neither element exceeds about 3%. The preferred range of composition is as follows:

Per cent chromium	17 to 28
Per cent carbon	Not over 0.25
Per cent molybdenum	2 to 4
Per cent columbium	At least 6 times carbon, but not exceeding 10 times carbon by more than 0.5%
Per cent manganese	Not over 1.5
Per cent silicon	Not over 0.6
Per cent nitrogen	Not over 0.2
Per cent iron	The remainder

One of the most useful novel embodiments of the invention is a container for aqueous saline solutions having a pH less than seven, such as exist in many industrial operations.

The steel of this invention is adapted to fabrication by ordinary known methods, by forging and rolling, and by welding, riveting and similar joining means.

As described in my copending application Serial No. 209,381, filed May 21, 1938, the steel of the invention may be used to form surface laminae or veneers in laminated articles having bodies of mild steel or of other steel containing less than 10% of elements other than iron. Such laminated articles may have any of the usual forms of sheets, plates, tubes, and the like. The veneer may cover a part or all of one or more than one surface of the body, as the design of the desired finished article may dictate.

I claim:

1. Alloy ferritic steel comprising 15% to 35% chromium, 1% to 5% molybdenum, 0.01% to 3% manganese, 0.01% to 3% silicon, 0.01% to 0.35% carbon, 0.01% to 0.5% nitrogen, and columbium in an amount at least four times the carbon content but not exceeding eight times the carbon content by more than 1.5%, the remainder iron.

2. Alloy ferritic steel comprising 17% to 28% chromium, 2% to 4% molybdenum, 0.5% to 1.5% manganese, 0.01% to 0.6% silicon, 0.01% to 0.25% carbon, 0.01% to 0.2% nitrogen, and columbium in an amount at least six times the carbon content but not exceeding ten times the carbon content by more than 0.5%, the remainder iron.

3. Articles which during normal use are subjected to corrosive saline solutions that tend to produce localized corrosion, said articles being resistant to such solutions and being composed of an alloy ferritic steel comprising 15% to 35% chromium, 1% to 5% molybdenum, 0.01% to 3% manganese, 0.01% to 3% silicon, 0.01% to 0.35% carbon, 0.01% to 0.5% nitrogen, and columbium in an amount at least four times the carbon content but not exceeding eight times the carbon content by more than 1.5%, the remainder iron.

4. Articles which during normal use are subjected to corrosive saline solutions having a pH less than seven that tend to produce localized corrosion, said articles being composed of an alloy ferritic steel comprising 17% to 28% chromium, 2% to 4% molybdenum, 0.5% to 1.5% manganese, 0.01% to 0.6% silicon, 0.01% to 0.25% carbon, 0.01% to 0.2% nitrogen, and columbium in an amount at least six times the carbon content but not exceeding ten times the carbon content by more than 0.5%, the remainder iron.

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