United States Patent Office

2,778,731

Patented Jan. 22, 1957

1

2,778,731

CORROSION-RESISTANT AUSTENITIC STEEL NOT REQUIRING NICKEL

Dennis J. Carney, Chicago, Ill., assignor to United States Steel Corporation, a corporation of New Jersey

No Drawing. Application November 19, 1953, Serial No. 393,219

2 Claims. (Cl. 75—126)

This invention relates to a corrosion-resistant, austenitic steel containing substantial amounts of chromium and manganese but little or no nickel.

The scarcity of nickel has led to many attempts in recent years to develop a substitute for all or part of it in conventional nickel-bearing stainless steels. The most desirable steel developed as a result of such attempts has substantially the following percentage composition:

C	.12 max. (aim .10).
Mn	15 min. (aim 17.5).
P	.04.
S	.03.
Si	.2–.7.
Cu	.5 max.
Ni	.99 max. (aim .75–.99).
Cr	15–16.
N	.20 max.
Fe	Balance.

Such steel, however, does not have as high a resistance to corrosion as desirable and exhibits poor forging and rolling qualities. Its austenite phase is unstable and the presense of nitrogen in excess of .20%, furthermore, leads to the production of unsound ingots manifesting excessive bleeding. A higher chromium content is desirable to increase corrosion resistance but causes an increase in ferrite as well as too numerous rejections for rolling defects.

I have invented an iron-chromium-manganese alloy which exhibits improved corrosion resistance and good rolling and forging qualities, as well as greater stability of austenite and desirable physical properties. In general, my alloy contains more chromium and considerably more nitrogen than known steels of the same type, and is relatively free of ferrite at high temperatures. In particular, the nitrogen should be at least .25% and may be as high as 1.0%. At a manganese level of 14 to 20%, the ratio of nitrogen to chromium, furthermore, should be from .015 to .035. This is contrary to the experience with steel of the analysis given above but, even with such increased amounts of nitrogen, the ingots are sound and free from porosity. Apparently the increased chromium plus manganese permits a higher nitrogen content without causing the bleeding of the ingots and the increased nitrogen dispenses with the need for any added nickel. There will usually be present, of course, a small or residual percentage of nickel, i. e., .2% or less.

2

The preferred ranges of percentage composition of my improved steel are:

C	.05–.15
Mn	14–17
Si	.25–1.0
P	.01–.05
S	.01–.08
Cr	17–18.5
Ni	.05–1.0
N	.25–1.0
Cu	0–1.0
Fe	Balance

A preferred example has the percentage composition:

C	.10
Mn	16
Si	.4
P	.05
S	.05
Cr	17.5
Ni	.10
N	.35
Cu	Residual
Fe	Balance

Such steel may be made by conventional practice. The nitrogen may be supplied by addition to the liquid steel of, for example, ferro-chromium containing nitrogen, or calcium cyanamide. The steel has better corrosion resistance and austenite stability (being relatively free of ferrite at high temperatures) than the chromium-manganese-nickel steel mentioned above, and also good physical properties. It also is easier to forge and roll at high temperatures. Ingots thereof are sound and non-porous. A nitrogen content of at least .25% is necessary along with at least 17% chromium and 14% manganese, to produce these results. More than 1% nitrogen is undesirable and more than 18.5% chromium or 17% manganese is unnecessary. The following table gives the composition of several further examples designated by heat numbers:

TABLE I

Chemical composition

Heat Number	C	Mn	P	S	Si	Ni	Cr	N
43	.14	19.86	.012	.010	.43	.11	18.35	.30
81	.08	20.02	.011	.006	.31	.08	18.00	.32
31	.11	19.80	.010	.060	.31	.05	17.90	.29
77	.09	18.80	.010	.004	.36	.16	18.30	.29
84	.10	18.24	.019	.012	.38	.08	18.04	.31
78	.10	17.78	.011	.013	.35	.12	18.16	.34
90	.09	15.83	.008	.011	.35	.83	17.47	.29
85	.10	15.12	.017	.014	.41	.10	17.59	.30
79	.10	14.94	.012	.013	.43	.13	18.12	.29
86	.09	15.32	.010	.014	.44	.08	17.80	.30
88	.13	17.18	.033	.010	.52	.05	18.26	.63
02	.10	17.41	.028	.013	.59	.09	18.66	.48
95	.08	18.87	.009	.014	.49	.18	19.83	.59
06	.07	19.45	.019	.005	.53	.06	18.74	.40

The following table gives the percentage of ferrite existing in the above examples when heated to different temperatures for various times:

TABLE II

Micro-structure

Hear Number	As Forged, percent	Percent Ferrite After Indicated Time at Temperatures			
		1,900° F.	2,100° F.	2,200° F.	2,300° F.
43	5-6	45 min., 1%	45 min., 2%		45 min., Trace.
81	5-6	45 min., 5-6%	45 min., 3-4%	120 min., 4 %	45 min., 7-8%.
31	5	45 min., 1%	45 min., Less 1%		45 min., None.
77	7-8	45 min., 6%	45 min., 6%	120 min., 8-9%	45 min., 10%.
84	6-7	90 min., 3%	90 min., 1-2%		90 min., 7-8%.
78	6	45 min., 5%	45 min., 2%	120 min., 3%	45 min., 5-6%.
90	4-5	90 min., 1%	90 min., 1%		90 min., 5-6%.
85	6	90 min., 2%	90 min., 1%		90 min., 7-8%.
79	5-6	45 min., 5-6%	45 min., 3-4%	120 min., 5%	90 min., 10%.
86	5-6	90 min., 2-3%	90 min., 2-3%		90 min., 5-6%.
88	None	90 min., None	90 min., None		100 min., None.
02	None	90 min., None	do		90 min., None.
95	1	90 min., 1%	90 min., Trace		90 min., 1%.
06	7-8	90 min., 7-8%	90 min., 3-4%		90 min., 10%.

The physical properties of the improved steel compare favorably with those of A. I. S. I. Types 301 and 302, except that the percent elongation is lower after cold-rolling. Such properties are given in the following table:

TABLE III

Heat Number	Condition	Hardness, Rockwell	Gauge	Yield Strength	Ultimate Strength	Percent Elongation
31	Hot-rolled, Annealed	B94.5	.1174	63,100	115,300	50.0
	Cold-rolled 10%	C30.0	.1086	101,000	130,800	32.0
	Cold-rolled 20%	C36.5	.0962	130,400	151,300	19.0
	Cold-rolled 30%	C40.0	.0845	154,400	182,000	9.0
43	Hot-rolled, Annealed	B94.5	.1250	64,550	116,000	50.0
	Cold-rolled 10%	C32.5	.1090	114,150	137,500	29.0
	Cold-rolled 20%	C37.5	.1003	139,700	163,400	15.0
	Cold-rolled 30%	C41.0	.0860		186,400	10.0
Type 301	Hot-rolled, Annealed			42,350	116,850	52.0
	Cold-rolled 10%			75,940	138,250	35.0
	Cold-rolled 20%			126,550	170,650	26.0
	Cold-rolled 30%			133,600	176,850	23.0
Type 302	Hot-rolled, Annealed			41,650	91,100	54.0
	Cold-rolled 10%			69,075	102,275	38.0
	Cold-rolled 20%			105,700	124,000	22.0
	Cold-rolled 30%			125,600	145,350	13.0

The corrosion resistance of my improved steel is but slightly less than that of A. I. S. I. Types 301 and 302 and noticeably better than those of the prior steel referred to above and straight chromium steel (A. I. S. I. Type 430).

It will be apparent from the foregoing that my improved steel is characterized by important advantages in its increased corrosion resistance, better rolling and forging qualities, greater stability of austenite, good physical properties and the facts that no nickel need be added and that the ingots are sound and free from porosity.

Although I have disclosed herein the preferred embodiment of my improved steel, I intend to cover as well any changes or modifications made therein which may be made without departing from the spirit and scope of the invention.

I claim:

1. Alloy steel consisting of from .06 to .15% carbon, from 14 to 20% manganese, from 17 to 18.5% chromium, from .05 to 1.00% nickel, from .25 to 1.0% silicon, from .25 to 1.0% nitrogen and the balance iron except for residual impurities usually present in such steel, the ratio of nitrogen to chromium being between .015 and .035, said steel exhibiting good corrosion resistance, good rolling and forging qualities and being highly austenitic.

2. Alloy steel comprising about .10% carbon, about 16% manganese, about 17.5% chromium, about .4% silicon, about .35% nitrogen and the balance iron except for residual impurities usually present in such steel, the ratio of nitrogen to chromium being about .02, said steel exhibiting good corrosion resistance, good rolling and forging qualities and being highly austenitic.

References Cited in the file of this patent

FOREIGN PATENTS

152,291 Austria ..... Jan. 25, 1938