United States Patent Office

2,835,571

Patented May 20, 1958

2,835,571

STEEL FOR USE AT ELEVATED TEMPERATURE

George V. Smith, Ithaca, N. Y., assignor to United States Steel Corporation, a corporation of New Jersey

No Drawing. Application July 2, 1957
Serial No. 669,431

3 Claims. (Cl. 75—126)

This invention relates to heat-treated chromium steels having improved stress-rupture strength at elevated temperatures and more particularly to heat-treated chromium steels of the 8% grade having improved creep to rupture stress.

Due largely to the development of high speed aircraft and missiles, there has been an urgent necessity for material possessing high stress-rupture strength at temperatures of the order of 1100° F. and which at the same time possess adequate corrosion resistance. Heretofore there has been some use made of the age-hardening austenitic-chromium steels containing upwards of 16% chromium with about 7% nickel. While possessing certain desirable qualities such as good corrosion resistance, such steels are quite high in price partly because of the large amount of expensive chromium and nickel alloying ingredients and partly because of difficulties in producing and processing them.

It is accordingly an object of the present invention to provide a heat-treated steel having the desired high temperature stress-rupture strength with only sufficient chromium to provide adequate corrosion resistance.

It is a further object to provide heat-treated steel of the 8% chromium type having a 100-hour stress-rupture strength in excess of 50,000 p. s. i. at 1100° F.

I have discovered that such stress-rupture resistance can be obtained in the 8% type chromium steel containing chromium, carbon, molybdenum, silicon and manganese within the following ranges, when heat treated in the specific manner hereinafter described. More particularly the steel should contain a maximum of .25% carbon, 7.50 to 8.25% chromium, 2.70 to 3.40% molybdenum, 3.00% maximum managnese and .75% maximum silicon, with the balance iron and other elements in amounts which do not adversely affect the properties. Thus for instance the steel may contain up to .5% titanium, up to .4% vanadium and up to .1% boron without these elements having any marked effect on the creep-rupture properties upon testing at 1100° F. after air cooling from 2200° F. and tempering 2 hours at 1100° F. To develop the desired properties, such steels should be heated to an austenitizing temperature between 1900 and 2200° F., transformed to a martensitic structure and

tempered at a temperature between 1100 and 1150° F.

With respect to the composition limits, carbon in excess of .25% has a harmful effect on the strength level. The minimum chromium and molybdenum contents are determined by the fact that lower amounts of these will not give the desired strength level nor, in the case of chromium will the necessary corrosion resistance be obtained. The upper limit of these elements is determined by the amount of delta ferrite that can be tolerated. If these amounts are exceeded, delta ferrite in excess of 30% will be present at the austenitizing temperature and therefore the steel will not be commercially forgeable.

A relatively few of the typical compositions tested are given in Table I.

Table I

	Steel	C	Mn	Si	Cr	Ti	Mo	V	Al	B	N
1	X-56	.15	------	.43	7.90	------	3.37	------	.11	------	.014
2	O-69	.14	.75	.46	7.88	------	.90	------	.075	------	.11
3	Z-70	.09	.68	.63	7.78	------	3.40	------	.013	------	.123
4	W-70	.11	.47	.56	7.73	------	2.75	------	.008	------	.077
5	O-72	.20	2.27	.40	7.71	.37	2.91	.12	.15	.013	.017
6	X-70	.11	.45	.53	7.55	------	1.80	------	.007	------	.081
7	Y-70	.09	1.01	.52	5.82	------	3.40	------	.013	------	.087

The creep-rupture strength at 1100° F. for these steels is given in Table II. The heat treatment consisted of air cooling from the indicated austenitizing temperature and tempering for 2 hours at 1100° F.

Table II

	Steel	Austenitizing Temperature, ° F.	100 Hr. Rupture Strength at 1,100 F., 1,000 p. s. i.
1	X-56	2,200	59
2	O-69	2,200	34
3	Z-70	2,000, 2,100 or 2,200	60
4	W-70	2,200	53
5	O-72	2,200	60
6	X-70	2,200	40
7	Y-70	2,200	44

The effect of varying heat treatment on the 100-hour creep-strength at 1100° F. is shown in the following Table III:

Table III

	Steel	Heat Treatment	100 Hr. Rupture Strength at 1,100 F., 1,000 p. s. i.
3	Z-70	1,900 A. C.—1,100 Temper	58.0
		2,000 A. C.—1,150 Temper	58.0
		1,900 A. C.—1,350 Temper	25.0
		2,000 A. C.—1,100 Temper	60.0
		2,100 A. C.—1,100 Temper	60.0
		2,200 A. C.—1,100 Temper	60.0

The effect of varying heat treatment on the 200-hour creep-strength at 1100° F. is shown in the following Table IV:

Table IV

	Steel	Heat Treatment	200 Hr. Rupture Strength at 1,100 F., 1,000 p. s. i.
3	Z-70	1,900 A. C.—1,100 Temper	52.0
		2,000 A. C.—1,100 Temper	54.0
		2,100 A. C.—1,100 Temper	53.4
		2,200 A. C.—1,100 Temper	52.1
		2,000 A. C.—1,150 Temper	50.3

This indicates that the optimum heat treatment involves austenitizing at about 2000° F., transforming to a martensitic structure and tempering at about 1100° F.

This application is a continuation-in-part of my copending application Serial No. 583,619, filed May 9, 1956, now abandoned.

While I have shown and described several specific embodiments of my invention, it will be understood that these embodiments are merely for the purpose of illustration and description and that various other forms may be devised within the scope of my invention, as defined in the appended claims.

I claim:

1. A forgeable ferritic chromium steel of the 8% type characterized by a high 100-hour stress-rupture strength at 1100° F. in the quenched and tempered condition, said steel containing .25% maximum carbon, 7.50 to 8.25% chromium, 2.70 to 3.40% molybdenum, 3.00% maximum manganese, .75% maximum silicon with the balance iron and other elements in amounts which do not adversely affect the properties.

2. A forgeable hardened and tempered ferritic steel of the 8% chromium type characterized by a 100-hour stress-rupture strength in excess of 50,000 p. s. i. at 1100° F., said steel containing .25% maximum carbon, 7.50 to 8.25% chromium, 2.70 to 3.40% molybdenum, 3.00% maximum manganese, .75% maximum silicon with the balance iron and other elements in amounts which do not adversely affect the properties, said steel having been austenitized at a temperature from about 1900 to 2200° F., transformed to a martensitic structure and tempered at a temperature between 1100 and 1150° F.

3. A forgeable hardened and tempered ferritic steel of the 8% chromium type characterized by a 100-hour stress-rupture strength in excess of 50,000 p. s. i. at 1100° F., said steel containing .25% maximum carbon, 7.50 to 8.25% chromium, 2.70 to 3.40% molybedenum, 3.00% maximum manganese, .75% maximum silicon with the balance iron and other elements in amounts which do not adversely affect the properties, said steel having been air cooled from a temperature of about 2000° F. and tempered at a temperature of about 1100° F.

References Cited in the file of this patent

UNITED STATES PATENTS

1,876,091 Strauss ---------- Sept. 6, 1932

FOREIGN PATENTS

Molybdenum-Steels, Irons, Alloys, 1948, page 158. Published by the Climax Molybdenum Co., New York, N. Y.