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[54] **PROCESSING FOR IRON-BASE ALLOY**

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[52] **U.S. Cl.** **148/12.3**, 148/37, 148/38

[51] **Int. Cl.** **C22c 39/20**, C22c 41/02, C21d 7/14

[58] **Field of Search**.......148/12.3, 38, 37; 75/128 W, 75/128 T, 128 B

[56] **References Cited**

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[57] **ABSTRACT**

An iron-base alloy of the nominal composition, by weight, of 15 percent chromium, 26 percent nickel, 1.3 percent molybdenum, 2.1 percent titanium, 0.3 percent vanadium, balance iron, is provided to provide a grain size of ASTM 5 or finer when measured at 1,000X magnification (normal ASTM grain size readings are at 100X magnification) with an ultimate tensile strength at room temperature of about 175,000 p.s.i.

3 Claims, No Drawings

PROCESSING FOR IRON-BASE ALLOY

BACKGROUND OF THE INVENTION

The present invention relates, in general, to the iron-base alloys and, more particularly, to novel processing therefor providing a significant increase in mechanical properties.

Aerospace Materials Specification AMS 5525 C describes an alloy of the nominal composition, by weight, of 15 percent chromium, 26 percent nickel, 1.3 percent molybdenum, 2.1 percent titanium, 0.3 percent vanadium, balance substantially iron. As specified in AMS 5525 C, this alloy as currently processed has a maximum tensile strength of 105,000 p.s.i. after solutioning and a minimum tensile strength after full heat treatment of 140,000 p.s.i.

There is an urgent demand in certain applications for a structural alloy having a strength of about 180,000 p.s.i. These strength requirements are satisfied by the nickel-base alloy specified in AMS 5597. However, for the particular application in mind, an iron-base alloy would be preferred to a nickel-base alloy because of an anticipated exposure of the alloy to a high pressure hydrogen environment. In such an environment hydrogen embrittlement is much more severe in the nickel-base alloys than those having basis in iron. Thus, it is extremely important, if not essential, to have available an iron-base alloy whose physical properties approach that of the AMS 5597 nickel-base alloy.

SUMMARY OF THE INVENTION

The present invention provides an iron-base alloy having physical properties equivalent to the AMS 5597 nickel-base alloy, particularly a minimum tensile strength at room temperature, in the fully heat treated condition, approaching 180,000 p.s.i.

The detailed specification chemistry for this alloy, as compared to the AMS 5525 C alloy is set forth in the following table:

TABLE I

Composition (percent by weight)

	This invention		AMS 5525 C	
	Min.	Max.	Min.	Max.
Carbon		0.08		0.08
Manganese		0.10		2
Silicon		0.25		1
Phosphorous		0.015		0.025
Sulfur		0.015		0.025
Chromium	13.5	16	13.5	16
Nickel	24	27	24	27
Molybdenum	1	1.5	1	1.5
Titanium	1.9	2.3	1.9	2.3
Boron	0.003	0.01	0.003	0.01
Vanadium	0.1	0.5	0.1	0.5
Aluminum		0.35		0.35
Iron		Balance		Balance

Rolling into sheet or strip conducted at a starting temperature of about 1,800° F. with working down to about 1,550° F. produces a grain size too small to rate by ASTM charts at 100X magnification. Cold rolling with low temperature annealing may also be utilized to produce similar microstructures. Subsequent to the rolling operation, processing is conducted at a temperature not exceeding 1,550°F., preferably in the range of 1350°F.–1,450°F. A low temperature stabilization thus replaces the high temperature solution heat

treatment. The alloy is then aged to provide maximum yield strength.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The conventional processing for the AMS 5525 alloy is as follows:

1. rolling between 2,000°F. down to 1,800°F.;
2. solution heat treatment at 1,800°F.;
3. and precipitation heat treatment at 1,325°F. for 16 hours.

The processing according to the comparative embodiment of the present invention involves the following parameters and sequence:

1. rolling at 1,800°F. down to 1,550°F.;
2. stabilization at about 1,400°F.;
3. and aging at about 1,300°F. for 16 hours. (optional)

The comparative results of the respective processing are summarized in the following tables and compared, where appropriate, to the AMS 5597 nickel-base alloy goal:

TABLE II

After step 1

	Present Invention	AMS 5525	AMS 5597
Tensile Strength p.s.i., max.	120,000	105,000	140,000
Elong.% in 2 in. min.	20	25	30
Rockwell Hardness (0.030 in.)	B90	B90	

TABLE III

After step 3

	Present Invention	AMS 5525	AMS 5597
Tensile Strength p.s.i., min.	175,000	140,000	180,000
0.2% Strength p.s.i., min.	160,000	95,000	150,000
Elong.% in 2 in. min.	18	15	15

The following tables summarize the effect of the processing on a material of the appropriate chemistry.

TABLE IV

Heat No. 8461 Rolled at 2,000°F.

Subsequent H.T. °F./hr./cool	Yield k.s.i.	Ultimate k.s.i.	% EL	% R/A
1800/1/OQ+				
1300/16/AC	98.4	158.2	27	44.7
(AMS 5525)	96.8	165.0	28	49.3
1700/1/OQ+	100.8	168.3	28	47.1
1300/16/AC				
1500/1/OQ+				
1300/16/AC	137.1	176.2	22	31.3
AC	138.8	176.3	20	36.5

TABLE V

Heat No. 8461 Rolled at 1,800°F.

Subsequent H.T. °F./hr./cool	Yield k.s.i.	Ultimate k.s.i.	% EL	% R/A

1800/1/OQ=				
1300/16/AC	93.9	166.5	27	45
	87.5	162.7	28	48.9
1700/1/OQ +				
1300/16/AC	106.1	178.3	24.6	36.0
1550/1/OQ+				
1300/16/AC	146.3	181.0	20	22.1
1450/1/OQ +				
1300/16/AC	163.0	186.5	19	34.0
1400/1/OQ +				
1300/16/AC	161.0	189.9	22	32
	159.8	186.0	20	31
1300/16/AC only	175.1	194.3	18	27
	159.8	186.4	20	21
1450/1/OQ no age	130.2	163	24	35.9

TABLE VI

Heat No. 8392 **Rolled at** 2000°F.

Subsequent H.T. °F./hr./cool	Yield k.s.i.	Ultimate k.s.i.	% EL	% R/A
1450/1/OQ +				
1300/16/AC	145.9	176	22	49.4
	147.1	173.6	26	50.9

Thus, it will be seen that the improved processing of the present invention provides an iron-base alloy having strength approaching that of the AMS 5597 nickel-base alloy, as desired.

Although the invention has been specifically described in detail in connection with specific examples and preferred embodiments, the invention in its broader aspects is not limited thereto, but departures may be made therefrom within the scope of the accompanying claims without departure from the principles of the invention and without sacrificing its chief advantages.

What is claimed is:

1. Alloy sheet at a composition of about, by weight, 13–16 percent chromium, 24–27 percent nickel, 1–2 percent molybdenum, 1.5–2.5 percent titanium, 0.003–0.01 percent boron, 0.1–0.5 percent vanadium, balance substantially iron, having at room temperature an ultimate tensile strength in excess of about 170,000 p.s.i. and an 0.2 percent yield strength in excess of about 150,000 p.s.i.

2. Iron-base alloy sheet at a nominal composition, by weight, of about 15 percent chromium, 26 percent nickel, 1.3 percent molybdenum, 2.1 percent titanium and 0.3 percent vanadium, having at room temperature an ultimate tensile strength of about 175,000 p.s.i. or higher and an 0.2 percent yield strength of about 160,000 p.s.i. or higher.

3. The method of producing sheet from an alloy of the nominal composition of about, by weight, 15 percent chromium, 26 percent nickel, 1.3 percent molybdenum, 2.1 percent titanium, 0.3 percent vanadium, balance substantially iron, which comprises:

rolling at a temperature not exceeding about 1,800°F.,

and subsequently aging the alloy at a temperature of about 1,300°F.,

the alloy after rolling being exposed to no sustained temperature in excess of about 1,550°F.

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