United States Patent Office

3,402,080

Patented Sept. 17, 1968

3,402,080

HIGH TENSILE STRENGTH STEEL ALLOYS

Hiroyuki Kubota and Junichi Tanaka, Kawasaki-shi, Japan, assignors to Nippon Kokan Kabushiki Kaisha, Tokyo, Japan

No Drawing. Filed Mar. 24, 1966, Ser. No. 536,983
Claims priority, application Japan, Apr. 13, 1965, 40/21,392
2 Claims. (Cl. 148—36)

ABSTRACT OF THE DISCLOSURE

The present invention relates to hardened and tempered steel alloys which contain relatively small amounts of vanadium and niobium and/or titanium. These steel alloys have high tensile strength and can be produced relatively cheaply and have a simpler composition than prior known high tensile strength steel alloys.

Prior steel alloys having high tensile strength, for example, of the order of from 70 to 80 kg./mm.^{2} are composed of very complicated compositions including very expensive elements and or elements which are very difficult to add stably, such as nickel, molybdenum, boron and the like so that it is necessary to prepare them with minute care. By this reason they are generally prepared by utilizing electric furnaces so that their cost of manufacture is extremely high.

This invention contemplates to obviate various difficulties mentioned above. When compared with conventional steel alloys having comparative strength, steel alloys of this invention are advantageous in that they are far cheaper and economic than prior alloys and especially that they can be readily prepared, in some cases even by convertors since they do not contain any unstable element. As a result, preparation and field of application of steel alloys having high tensile strength of the order of from 70 to 80 kg./mm.^{2} are widened.

More particularly, the steel alloy of this invention is consisted of from 0.10 to 0.2% of carbon, from 0.10 to 0.70% of silicon, from 1.00 to 2.00% of manganese, from 0.10 to 0.50% of copper, from 0.10 to 0.70% of chromium, from 0.01 to 0.20% of vanadium, from 0.01 to 0.10% of niobium, or titanium or both, and the balance of iron and impurities, said steel alloy being hardened and tempered to provide high tensile strength of the order of from 70 to 80 kg./mm.^{2}.

The reason of adopting the above mentioned ranges of ingredients is as follows: The lower limits for carbon and silicon correspond to the minimum values necessary for providing the required strength while therein upper limits correspond to the maximum values which are required so as not to impair the weldability of the steel alloy. The lower limit for manganese is the value which is necessary to assure the required strength, but the upper limit therefor corresponds to the maximum value above which the weldability is affected. Although incorporation of copper is effective to improve anticorrosion property and strength of the alloy but incorporation thereof above said upper limit causes rapid decrease of hot workability. While chromium is a preferable element for increasing anticorrosion property, according to this invention it is incorporated only when high strength is desired. Further vanadium is the most important element that contributes to increase the strength of the alloy steel, but stiffness and properties of the product are greatly reduced with the increase in the quantity of incorporation of vanadium. By this reason, in prior steel alloys containing lesser quantity of alloying ingredients it has been the practice to incorporate vanadium in excess of about 0.1%. However in the

steel alloy embodying this invention inasmuch as the austenite grains are rendered very fine, the impact property of the alloy steel has been greatly improved so that it becomes possible to incorporate vanadium of substantial quantity as mentioned above. As a result, it is possible to produce alloy steels having high tensile strength of the order of from 70 to 80 kg./mm.^{2} without impairing the stiffness notwithstanding their composition of low cost.

Table 1 below shows typical compositions of the high tensile strength of steel alloys of this invention containing lesser amount of alloying ingredients and examples of compositions of control samples, wherein sample members from A to M representing the novel steel alloys and sample members from O to T control samples not embodying this invention.

TABLE 1.—CHEMICAL COMPOSITIONS

Sample No.	Chemical Composition (Percent)							
	C	Si	Mn	Cu	Cr	V	Nb	Ti
A	0.12	0.36	1.33	0.20	0.10	0.19	0.05	------
B	0.17	0.62	1.35	0.24	0.11	0.08	0.04	------
C	0.17	0.62	1.45	0.24	0.13	0.16	0.05	------
D	0.15	0.64	1.72	0.27	0.11	0.04	0.05	------
E	0.20	0.11	1.13	0.28	0.12	0.11	0.04	------
F	0.19	0.63	1.45	0.26	0.15	0.08	------	0.01
G	0.19	0.59	1.37	0.25	0.14	0.08	------	0.03
H	0.18	0.62	1.54	0.26	0.26	0.01	------	0.01
I	0.17	0.63	1.39	0.24	0.12	0.13	0.06	------
J	0.15	0.64	1.73	0.27	0.13	0.01	0.04	------
K	0.15	0.64	1.74	0.28	0.33	0.04	0.05	------
L	0.14	0.64	1.79	0.27	0.12	0.08	0.04	------
M	0.20	0.69	1.55	0.26	0.11	0.08	------	0.06
O	0.21	0.09	1.09	0.28	0.03	0.03	0.05	------
P	0.09	0.38	1.25	0.21	0.16	0.06	0.04	------
Q	0.18	0.13	0.98	0.16	0.23	------	0.05	------
R	0.17	0.63	1.65	0.44	0.71	------	------	------
S	0.18	0.12	1.44	0.06	0.05	0.06	------	------
T	0.17	0.62	1.20	0.27	0.01	------	0.09	------

The mechanical characteristics of various samples shown in Table 1 is as shown in Table 2 below. In Table 2, the distance between marker points utilized to determine elongation was set to 50 mm., and Eo shows impact values at 0° C. obtained by using a 2 mm. V Charpy impact test machine.

TABLE 2.—MECHANICAL CHARACTERISTICS

Sample No.	Yielding point, kg./mm.^{2}	Tensile strength, kg./mm.^{2}	Elongation, percent	Reduction, percent	Eo, kg./cm.
A	65.6	74.3	26	69	9.0
B	61.3	72.5	28	64	10.0
C	60.3	70.9	29	71	18.0
D	64.3	72.2	26	70	17.5
E	62.5	73.0	27	67	10.9
F	68.0	77.0	25	65	14.5
G	60.0	70.2	29	70	19.6
H	61.3	73.8	26	68	16.8
I	66.1	80.3	23	61	9.1
J	71.6	78.4	27	66	9.5
K	81.5	86.6	21	61	16.3
L	72.9	79.1	25	71	10.5
M	73.1	80.1	23	66	11.1
O	53.2	64.7	30.0	68	13.3
P	50.0	59.0	29.0	74	25.0
Q	55.8	62.7	29.0	66	10.8
R	65.3	75.5	28.0	68	2.6
S	58.4	71.4	24.0	64	5.1
T	48.0	61.3	34.0	67	12.9

As can be noted from the foregoing description this invention provides alloy steel of high tensile strength of the order of from 70 to 80 kg./mm.^{2} without using expensive nickel and molybdenum, thus providing such high tensile strength steels at very cost. Further, since the alloy steels of this invention are not added with boron which is unstable and has a tendency to harden them it is very easy to prepare them. Further, the incorporation of vanadium improves the high temperature property while incorporation of niobium or titanium assures sufficient stiffness of the alloy steel. Moreover, the fact that the types

of elements incorporated are less and that no boron is incorporated makes it possible to produce steels of high tensile strength of the order mentioned above at low cost by converters. Thus the field of application of such high quality steels is greatly broadened.

While there have been shown and described particular embodiments of the invention, it will be obvious to those skilled in the art that changes and modifications may be made without departing from the true spirit and scope of the invention as defined in the appended claims.

What is claimed is:

1. A hardened and tempered steel alloy of high tensile strength, said alloy consisting essentially of about 0.10 to 0.20% of carbon, about 0.10 to 0.70% of silicon, about 1.00 to 2.00% of manganese, about 0.10 to 0.50% of copper, about 0.10 to 0.70% of chromium, about 0.10 to 0.20% of vanadium, about 0.01 to 0.10% of both niobium and titanium, and the balance of iron and impurities.

2. Alloy according to claim 1 wherein said alloy contains about 0.01 to 0.10% of niobium only instead of both niobium and titanium.

References Cited

UNITED STATES PATENTS

1,812,155	6/1931	Klinkenberg	75—125
2,280,796	4/1942	Comstock	75—125
2,474,766	6/1949	Waggoner et al.	75—125

FOREIGN PATENTS

471,046	8/1937	Great Britain.
802,855	10/1958	Great Britain.
297,952	1932	Italy.
1,182,845	12/1964	Germany.

OTHER REFERENCES

Welding Journal, vol. 33, No. 5, May 1954, pp. 251s–256s.

CHARLES N. LOVELL, *Primary Examiner.*