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LOW-ALLOY TOUGH STEEL

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1 Claim. (Cl. 75—124)

This invention relates to low-alloy tough steels or more particularly to a tough steel containing no nickel and vanadium.

When a tough steel, having the high strength and toughness necessary for construction of machines, is quenched, it will uniformly harden and, when it is properly tempered, its toughness will be increased.

The kind of steel which is generally used as a tough steel it a steel having a carbon conent of about 0.25 to 0.50% and in addition, having a proper amount of such elements as silicon, mananese, chromium, nickel, molybdenum and vanadium. It is used as quenched and then tempered at 550 to 650° C. so as to have the sorbite structure.

Further, so-called T–1 steel which has the toughness, ductility and weldability of a low-carbon steel is known and extensively used as a tough steel though it is not used in a low-temperature tempered state.

However, the steel, mentioned above, has costly nickel and vanadium added thereto in order to obtain the desired mechanical properties and therefore is expensive.

Furthermore, this steel has weak resistance against stress-corrosion in an atmosphere containing hydrosulphide or ammonia.

An object of the present invention is to provide an inexpensive low-alloy tough steel containing no costly nickel and vanadium as alloying elements but having the same or better mechanical properties, anticorrosiveness, stress-corrosion resistance and weldability as the said type of known tough steel.

The low-alloy tough steel of the present invention is composed of less than about 0.25% carbon, less than about 0.5% silicon, about 0.50 to 1.50% manganese, about 0.80 to 2.0% chromium, about 0.2 to 0.6% molydenum, about 0.01 to 0.15% aluminum, 0.005 to 0.0003% boron, less than about 0.05% titanium with the remainder being iron and unavoidable impurities.

The low-alloy tough steel of the present invention is used as quenched and tempered or as normalized or normalized and tempered.

The ranges of the contents of the respective alloying elements in the present invention are limited in such a sence as is mentioned below.

The carbon content should be less than .25% in order to increase the toughness of the steel at low temperatures and to improve the weldability. At least 0.5% manganese must be present in refining the steel in order to increase the low-temperature toughness. If there is more than 1.50% manganese, the weldability of the steel is reduced and the cost of the steel is high. Chromium increases the hardenability, strength and low-temperature toughness, improves the anticorrosiveness in the air and in an atmosphere of hydrosulphide or mamonia, prevents thickness reduction of the steel due to corrosion, satisfying one of the requirements for lightening the weight of structures by the use of such kind of steel. However, as in the case of manganese, when is more than

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2.00% chromium is present, the weldability of the steel is reduced and the production cost becomes high. Therefore, the amount of chromium should be about 0.80 to 2.00%. About 0.2 to 0.6% molybdenum is added for the purpose of increasing the hardenability of the steel, preventing the steel from becoming brittle when tempered, increasing the resistance to tempering, expanding the cooling velocity range for the production of bainite by the mutual action with boron and giving a stable strength.

Boron increases the hardenability without reducing the weldability, makes the addition of nickel and other elements unnecessary, serves to reduce the production cost and stabilizes the strength by the mutual action with molybdenum. However, the addition of more than 0.005% boron will reduce the hot-workability. The addition of less than 0.0003% will have no effect.

Titanium, combining with nitrogen in the steel, prevents the effective amount of boron from being reduced by free nitrogen and increases the resistance to tempering. But, when a large amount of titanium is added, the toughness will be reduced. Therefore, the titanium content should be less than 0.05%. However, when the thickness of the plate is less than 25 mm., there is no need to add titanium because the hardenability will be sufficiently high that the titanium will have no effect on the hardening.

In order to secure an effective amount of titanium by deoxidation and to refine the austenite grain size, about 0.01 to 0.15% aluminum is added. So much silicon is added as is required for making the steel.

Table 1 shows specific examples of chemical compositions of low-alloy tough steels according to the present invention. Table 2 shows the chemical properties of the said tough steels.

TABLE 1.—EXAMPLES OF CHEMICAL COMPOSITIONS OF LOW-ALLOY TOUGH STEELS ACCORDING TO THE PRESENT INVENTION

Sample signs	C	Si	Mn	Cr	Mo	B	Ti	Al
A	0.12	0.30	0.67	1.12	0.51	0.0014	0.033	0.026
B	0.20	0.31	0.63	1.16	0.30	0.0014	0.066	0.029
C	0.18	0.19	0.80	1.03	0.30	0.0037	0.018	0.041
D	0.10	0.25	1.13	1.50	0.20	0.0023	0.025	0.018
E	0.15	0.27	1.20	1.37	0.25	0.0021	0.017	0.020

TABLE 2.—EXAMPLES OF MECHANICAL PROPERTIES OF THE ALLOY STEELS IN TABLE 1

Sample signs	Results of tension tests (JIS No. 4)			Results of impact test		Heat treatment
	Yeilding point in kg./mm.²	Tensile strength in kg./mm.²	Elongation in percent	VTr 15 (° C.)	VTrS (° C.)	
A	75.1	83.1	20.0	−113	−80	Water-quenched at 900° C. and tempered at 600° C.
B	88.8	95.3	18.2	−60	−10	Do.
C	82.5	91.1	18.8	−90	−50	Do.
D	69.2	78.5	23.2	−108	−85	Do.
E	84.2	93.8	19.3	−98	−68	Do.

As evident from the above tables, in the low-alloy tough steels of the present invention, the tempering temperature can be elevated, thereby preventing lowering the strength after annealing to remove stresses and improving the toughness.

What I claim is:

A low-alloy tough steel composed of less than about 0.25% carbon, less than about 0.5% silicon, about 0.50 to 1.50% manganese, about 0.80 to 2.0% chromium, about 0.2 to 0.6% molybdenum, about 0.01 to 0.15% aluminum, 0.005 to 0.0003% boron, about 0.017 to 0.05% titanium and the remainder being essentially iron.

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