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SEA-WATER CORROSION RESISTING STEEL CONTAINING ALUMINUM FOR WELDING STRUCTURES

Hiroyuki Kubota, Akihiro Tamada, and Motonori Uemura, Yokohama, Japan, assignors to Nippon Kokan Kabushiki Kaisha, Kanagawa-ken, Japan

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ABSTRACT OF THE DISCLOSURE

A steel whose sea-water corrosion resistability is maintained and improved with the addition of alloying elements which are basically Cu, Cr and Al in place of P and Cu and more particularly the weldability of said steel is improved with the addition of more than 0.30% Al.

This invention relates to a steel having high sea-water corrosion resistibility and more particularly directed to a steel having excellent weldability.

It is well known that "U.S. S Mariner Steel" is generally employed as good sea-water corrosion resisting steel for the so-called "splash zone" and in an environment where the metal is alternately wet and dry. The features of said "U.S. S Mariner Steel" lie in that the chemical composition consists in a P-Cu-Ni system. It is confirmed that the above steel has greater resistance to seawater "splash zone" corrosion and longer life in a marine environment. It is, however, an undeniable fact that there is a knotty point in the weldability of said "U.S. S. Mariner Steel."

The present steel is developed in order to work out said welding problem. The first feature of this present steel lies in that P content is limited to the range of unavoidable impurities. Accordingly, corrosion resistibility, high strength and long life in a marine environment is assured by which the chemical composition consists in a Cu-Cr-Al-Ni system. This is the second feature of this present steel. Still more, when Sb, Sb+Sn or Sb+As is added to the above composition, said properties of this invention steel are possible to be improved.

An object of this invention is to provide a sea-water corrosion resisting steel having higher weldability.

Another abject of this invention is to provide a sea-water corrosion resisting steel with which the resistibility is superior to other steels.

Other objects of this invention will become apparent in the following description.

The basic composition of this invention is as follows:

Maximum 0.20% C,
Maximum 0.60% Si,
Maximum 1.50% Mn,
less than 0.04% P and S,
0.20 to 0.60% Cu,
0.50 to 3.0% Cr,
0.30 to 3.0% Al, and
0.20 to 0.50% Ni.

The second composition of this invention consists in adding 0.05 to 0.20% Sb to the above composition.

The third composition of this invention consists in adding 0.05 to 0.10% Sn to the second composition.

The fourth composition of this invention consists in adding 0.05 to 0.10% As to the second composition.

In this invention, the reason why the alloying elements are limited to the range as mentioned above will become understood from the following description.

When C content is above 0.20%, corrosion resistibility, particularly weldability of steel changes to the worse. Consequently, said steel will be impossible to be employed for welding structures.

Si content should be limited to the range in which a change of weldability for the worse can be avoided. Otherwise, hardness of said steel will increase and cracking of said steel will be brought about. Maximum 0.60% Si is determined for the above mentioned reasons. Such Si content is enough to deoxidize said steel and keep the strength of said steel.

More than 1.50% Mn brings about an unnecessary increase of said strength and makes workability of said steel worse.

P is an element for improving sea-water corrosion resistibility in coexistence with Cu. However, P also is an element making remarkably worse. Accordingly, P content of this invention should be kept within range of unavoidable impurities, i.e., less than 0.04%. While S also makes said steel worse and the upper limit is 0.04%.

The sea-water corrosion resistibility can be remarkably improved owing to coexistence of Cu, Cr and Al. This is the biggest feature of this invention. According to many experiments, it is confirmed that the coexistance of Cu, Cr and Al shows excellent multiplied effects as mentioned hereafter;

This is, first, on of said multiplied effects is that polarizing action of anode and cathode is enlarged over that of adding only one element. Secondly, a hard, closely and thickly stained layer is formed on the surface of said steel. Such an early corrosion layer keeps said steel from the further progress of said corrosion that is, the passivity of said primary corrosion layer.

It is, furthermore, confirmed that the multiplied effects wherei Sb, Sb+Sn or Sb+As is further added are larger than that of said Cu+Cr+Al system.

In such a case, the content of said alloying elements is as follows respectively:

The reason why the lower limit of the Cu content is determined to be 0.2% lies in keeping good corrosion resistibility of the steel. When the Cu content is more than 0.60%, cracks and flaws on the surface of steel will increase.

The reason why lower limits of Cr and Al is determined to be 0.50% and 0.30% respectively also lies in keeping good corrosion resistibility. When both the Cr and Al contents are more than 3.0%, it is evident that workability of said steel changes for the worse and pitting attach occurs.

Sb, Sn and As contents which are less than 0.05% are impossible to improve said corrosion resistibility, even though the above elements are added at the same time. The reason why the upper limit of the Sb content is determined to be 0.20% lies in keeping good hot-workability and excellent weldability. By a similar reason, upper limit of Sb and Sn, which is added at the same time, is determined to be 0.15% and 0.10% and that of Sb and As is 0.15% and 0.10%.

Addition of 0.20 to 0.50% Ni, which has little effect in improving said corrosion resistibility, however, has the effect of making the corrosion surface smoother and consequently does much for keeping the passivity of said produced corrosion layer, because of preventing a pitting attack, is for preventing said steel from so-called Cu-flaws in the hot-rolling state.

Other features of this invention are to add Al of 0.30 to 3.0% for the purpose of improving said weldability. Simultaneously, Al is an element for increasing said corrosion resistibility unlike the above-mentioned P. It is possible to prevent the welding portion from any crack by addition of more than 0.30% Al.

The tested results of Cu+Cr+Al system steels, which are examples of this invention steels is shown in Table I and those of Cu+Cr+Al+Sb system,

Cu+Cr+Al+Sb+Su

system and Cu+Cr+Al+Sb+As system, in Table II.

In the below-mentioned tables, the corrosion rate is shown as a ratio to which that of common steel is 100%.

According to the above tested results, it will be evident that the corrosion resistibility of this invention is superior to common and comparative steels.

It is a matter of course that such a steel is the one best suited which can be widely employed in sea-water applications as sheet, plate, tubing, bar and section.

0.60% Si, maximum 1.50 Mn, up to 0.04% P and S, 0.20 to 0.60% Cu, 0.50 to 3.0% Cr, 0.30 to 3.0% Al, 0.20 to 0.50% Ni, 0.05 to 0.15% Sb, 0.05 to 0.10% Sn unavoidable impurities and the balance being Fe.

4. A sea-water corrosion resisting steel for welding structures composed of maximum 0.20% C, less than 0.60% Si, maximum 1.50% Mn, up to 0.04% P and S, 0.20 to 0.60% Cu, 0.50 to 3.0% Cr, 0.30 to 3.0% Al, 0.20 to 0.50%, Ni, 0.05 to 0.15% Sb, 0.05 to 0.10% As, unavoidable impurities and the balance being Fe.

TABLE I

[Test of exposure in sea water; period is one year]

	Chemical compositions									Corrosion rate, percent
	C	Si	Mn	P	S	Cu	Cr	Ni	Al	
Common steel A	0.12	0.39	1.06	0.015	0.014					100
Comparative steel:										
B	0.14	0.49	0.84	0.018	0.019	0.32				91.4
C	0.15	0.54	0.95	0.014	0.028	0.80				85.2
D	0.11	0.12	0.46	0.017	0.014	0.38	1.05			80.7
E	0.11	0.24	0.45	0.018	0.017	0.41	2.88			71.2
F	0.12	0.38	0.51	0.019	0.016	0.37			0.669	80.3
G	0.11	0.37	0.50	0.024	0.013	0.43			2.145	73.1
Invention steel:										
H	0.17	0.40	0.82	0.015	0.007	0.41	0.60	0.30	0.374	69.4
I	0.08	0.36	0.81	0.013	0.005	0.38	2.02	0.32	0.71	55.6

TABLE II

[Test of exposure in sea water; period is one year]

	Chemical compositions												Corrosion rate, percent
	C	Si	Mn	P	S	Cu	Cr	Ni	Al	Sb	Sn	As	
Common steel A	0.12	0.39	1.06	0.015	0.014								100
Invention steel:													
J	0.09	0.54	0.68	0.013	0.008	0.42	1.98	0.32	0.74				55.4
K	0.08	0.48	0.70	0.015	0.013	0.45	1.90	0.33	0.65	0.097			49.8
L	0.08	0.47	0.67	0.009	0.015	0.44	1.95	0.31	0.58	0.200			44.4
Comparative steel:													
M	0.09	0.48	0.62	0.013	0.006	0.41	1.98	0.32	0.68		0.112		55.0
N	0.09	0.55	0.66	0.013	0.005	0.43	1.98	0.32	0.68		0.198		54.2
O	0.09	0.46	0.65	0.015	0.005	0.42	1.91	0.33	0.66			0.099	55.2
P	0.08	0.48	0.61	0.014	0.005	0.43	1.99	0.31	0.63			0.199	54.6
Invention steel:													
Q	0.08	0.50	0.66	0.017	0.003	0.47	2.00	0.31	0.66	0.089	0.096		46.1
R	0.08	0.52	0.64	0.012	0.005	0.44	1.96	0.32	0.63	0.105		0.102	49.3

We claim:

1. A sea-water corrosion resisting steel for welding structures composed of maximum 0.20% C, less than 0.60% Si, maximum 1.50% Mn, up to 0.04% P and S, 0.20 to 0.60% Cu, 0.50 to 3.0% Cr, 0.30 to 3.0% Al, 0.20 to 0.50% Ni, unavoidable impurities and the balance being Fe.

2. A sea-water corrosion resisting steel for welding structures composed of maximum 0.20% C, less than 0.60% Si, maximum 1.50% Mn, up to 0.04% P and S, 0.020 to 0.60% Cu, 0.50 to 3.0% Cr, 0.30 to 3.0% Al, 0.20 to 0.50% Ni, 0.03% to 0.20% Sb, unavoidable impurities and the balance being Fe.

3. A sea-water corrosion resisting steel for welding structures composed of maximum 0.20% C, less than

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HYLAND BIZOT, Primary Examiner

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