For Mild & High Tensile Strength Steel Use

Materials General Review

Steels are categorized by the base of the amount of carbon content but not by silicon (Si), manganese (Mn) or other elements. If we review many different steel specifications, we will see Si or Mn contents are much more than Carbon, but they are not used for steel categorizing, why?

As we know, almost of carbon (but may not be all) in steels are converted into Fe_3C which is a very hard and high strength compound material we called it as cementite, the amount of cementite is the major factor to decide steel properties such as hardness and tensile strength.

Let us see the molecular Fe_3C in detail, the atomic weight of C is 12 and the Fe is about 55.8, the weight of 3 Fe atoms plus 1 C atom is about 179.5, C occupies weight rate is only about 6.68%. In other words, the weight of 1 atom C can make 15 times weight of cementite. For 0.3% carbon steel as an example, suppose all 0.3% carbon is converted into Fe_3C, the weight of Fe_3C rate can be about 4.5%. Cementite weight ratio can vary 15 times by slightly varying of C content. This is a very important understanding to know why there is a big change of steel mechanical properties only by small amount change of C content.

In general, steels with C content ≦ 0.3% are mild or low carbon steels; > 0.3% but ≦ 0.5% are medium carbon steels; > 0.5% are high carbon steels.

The hardening of Heat Affected Zone (HAZ) is a major detriment factor to a weldment, and the degree of HAZ hardening tendency can be used to evaluate the weld ability of steel. It is not only affected by C content but also by Mn, Si and other elements those have different affection level as C does. The Carbon Equivalent is the summary of Carbon content plus other alloy elements each of those is divided by a specific number due to different hardening affection level as compared to carbon. The higher the Carbon Equivalent, the poor the weld ability a steel is (high possibility of cold cracking induced by high hardening tendency), so it is a very common and useful data to determine whether a steel is easy or difficult to weld and can be the welding control base to give necessary pre-heating and inter-pass temperature.

The Carbon Equivalent calculation formula is shown as following :
Ceq.= C + Mn / 6 + Si / 24 + Ni / 40 + Cr / 5 + Mo / 4 + V / 1 4 (%) (JIS)
or
Ceq.= C + Mn / 6+1/5 (Cr+Mo + V) + 1/15 (Ni + Cu) (IIW, International Welding Institute) (%)

The value of Ceq., C, Mn, Si, Ni, Cr, Mo, V etc. are weight percentage of a steel.

When Ceq. ≦ 0.4% and HV< 350, the steel has good weld ability and seldom welding crack happened. It is absolute necessary to preheat before welding when Ceq and Hardness are over above values.

The relation between Ceq. and HAZ hardness can be approximately calculated by following formula :
HV max = 1200 x Ceq - 200

Welding Consumables Selection

AWS specification (A5.1)		—	E6010 E6011	E6013	E6019	E6027	E7016	E7018	E7024	E7028	E7048
JIS specification		E4303	E4310 E4311	E4313	E4319	E4327	E4916U H10	E4918 H10	E4924	E4928U H15	E4948 H10
Covered category		lime-titania	high cellulose potassium	high titania potassium	ilmenite	high iron oxide, iron powder	Low Hydrogen Type	low-hydrogen potassium, iron powder	iron powder, titania	low-hydrogen potassium, iron powder	Low Hydrogen Type
Welding performance											
crack resistant ability		○	○	○	○	○	☆	☆	○	◎	☆
RT ray detection inspection performance		○	○	○	○	○	☆	☆	○	◎	◎
Impact performance		○	○	○	○	○	☆	☆	○	◎	◎
Operation ability											
welding positions	Flat position	☆	○	☆	◎	○	○	○	○	○	—
	Horizontal fillet position	☆	○	☆	◎	☆	○	○	☆	☆	—
	Vertical upward position	△	○	○	◎	—	☆	☆	—	—	—
	Vertical downward position	—	☆	◎	△	—	—	—	—	—	☆
	Horizontal and overhead position	△	☆	◎	◎	—	○	○	—	—	—
Bead appearance	Flat position	☆	△	☆	○	○	○	○	○	○	—
	Horizontal fillet position	☆	△	☆	○	☆	○	○	☆	☆	—
	Vertical, overhead or horizontal position	△	☆	◎	○	—	◎	◎	—	—	☆
penetration depth		○	☆	△	◎	△	○	○	△	△	○
re-arc ability		☆	☆	☆	○	☆	—	—	☆	☆	△
welding spatter quantity		○	△	◎	○	◎	○	○	◎	◎	○
slag removal ability		☆	○	◎	○	◎	◎	◎	◎	◎	☆
welding speed		◎	△	○	○	◎	○	○	◎	◎	☆
good for thin plate		◎	△	☆	○	△	△	△	△	△	△

Note: ☆: Excellent, ◎ : Good, ○ : Normal, △: Poor, —: NA

This information is for reference only, welcome to consult us if any further detail require