Cast Iron

Materials General Review

1. Any iron alloy containing Carbon content 2.5~4%, Si 0.5%~3.0%, Mn 0.3%~1.2%, P 0.1~0.6%, and S 0.02~0.12% is categorized as cast iron. Certain special applications or usages may require the addition of Cr, Cu, Ni, Mo, V, Ti and other elements.

2. Cast iron is separated into four major categories: Gray cast iron; Malleable cast iron; Nodular cast iron, and White cast iron depending mostly on its C and Si elemental contents.

3. If the metal's C and Si content is low (C < 3.0%, Si < 2.0%), and is free of dissolute free graphite, it is categorized as White Cast Iron.
   If the elemental contents are higher than above description, it is then categorized as Gray Cast Iron (there are Ferrite type, Pearlitic type and mixing type depending on the different content in matrix structure).
   If add some Ca, Mg elements during the casting process, that will make graphite to form spheroidal structure of nodular cast iron, both toughness and ductility are better than gray cast iron, mechanical properties are equal to general mild steel.
   If the white cast iron prolonged heating at 850˚C ~ 930˚C temperature range, so that some micro-structure produce the graphite to form the black heart malleable cast iron.
   if the temperature up to 1000˚C and prolonged heating in the Fe-O (Ferric oxide) powder will become the white heart malleable cast iron, which mechanical property is better than gray cast iron.

4. The graphite in cast iron during the solidify process will suffer expansion phenomenon, which negates the contraction effect of metallic solidification; and thus, the higher the C and Si content, the less conspicuous is its expansion and contraction process.

5. Due to cast iron's low melting point, it has the qualification of being easily mold into complex shapes; it is thus widely used industrially, although it suffers from poor weld-ability for the following reasons :
   a. Welding area may endure secondary hardening effect due to rapid cooling, which worsens its machining and cutting ability.
   b. The welding process will produce large amount of CO_2, and create blow hole due to high carbon content.
   c. Poor ductility in conjunction with heat stress during welding process will produce cracks in the fusion zone.
   d. The rich content of cementite will cause cracks if the welding process's expansion and contraction variance is too great.
   e. Both higher preheat temperature than normal and high welding skill are required.

Welding Consumables Selection

Products	Slag type	Preheat temp. °C	Wetting effect	Color matching between base & weld metal	Joint weldability	Crack resistance	Weld metal & HAZ machinability	Alloy content	Cost
GC100	Graphite	100~300	○	△	◎	◎	◎	Ni:99%	very expensive
GCI-1	Graphite	100~300	○	△	◎	◎	◎	Ni:99%	very expensive
GC55	Graphite	150~350	○	△	○	○	○	Ni:55%	expensive
GCI-2	Graphite	150~350	○	△	○	○	○	Ni:55%	expensive
GC0	Low hydrogen	100~350	◎	○	○	△	△	Low alloy Low hydrogen Fe:Bal.	cheap
GCI-3	Graphite	350~400	○	◎	○	△	△	C:3.2% Fe:Bal.	cheap

Note: ◎Excellent，○Good，△Poor

Welding Notes

1. The defects on the welding surface of the casting or the repair welding area can be eliminated through the processes of machining, grinding, chipping and etc. Grease, filth, and other detrimental matter on the base metal can be cleaned using solvents; however, if the solvent permeate the base metal due to inclusion by capillary effect, increasing the temperature to 400°C will resolve this issue. If the grease is overwhelming and it infiltrates deeply in the surface of base metal, raising the temperature to 540°C will completely eliminate the grease.

2. V type groove angle : 60~80˚;
   U type groove angle : 20~25˚, root radius : 4.8~13mm (for heavy work use).

3. It is recommended to use the lower limit of suggested welding current according to the welding positions in order to achieve proper fusion with the base metal; furthermore, to obtain a smooth bead appearance, employing skilled welders is highly preferred.

4. Use string bead is mainly. If weaving is desired, the weaving width should not exceed 3 times the core wire diameter (the weld surface bead width is approximately 4 times of the core wire diameter). If weld groove is cavity type, the edge needs grinding in order to get wider groove face so that the repair surface can be smooth.

5. If the casting is heavy, in order to achieve even spread of welding heat, intermittent welding technique is recommended; in addition, keep the weldment in a constant lukewarm state during welding.

6. The hardness of HAZ is usually affected by base metal composition and cooling rate. An appropriate preheat can ease the hardening of HAZ. Dilution level might affect weld metal hardness which should be controlled by proper welding procedure and parameter, Normally, the dilution rate of single-pass welding is higher and leads to higher weld metal hardness.

7. When the weldment is the pressure part and there is big thickness difference between base metals to be jointed. Proper preheating will even the cooling and achieve better crack prevention.

8. Peening is appropriate when the weldment still remain at high temperature (about 540° C) after welding; however, it is inappropriate to apply at the root pass(es) and surface finishing pass(es).

9. Large weldment's weld metal cracks easily. Apply stud planting method on the weld groove face before welding to prevent crack. The stud diameter should be about 6.4~16mm. The planted depth into the base metal groove face should be about the stud diameter and the protruding part above the weld groove face is about 4.8~6.4mm.
   The stud should occupy 25-35% of the weld sectional area.