Cast Iron-properties-types and weldability

Objectives: At the end of this lesson you shall be able to
- **explain the properties of cast iron and its types**
- **explain the method of edge preparation**
- **describe the cast iron welding technique**
- **select filler rods for the jobs to be welded by gas.**

Cast iron is widely used in the manufacture of machine parts, since it has a good compressive strength and easy to make the castings. There are different problems in the welding of cast iron in comparison to mild steel, even though this is also in the group of ferrous metals.

Types of cast iron

There are four basic types of cast iron available.

- Grey cast iron
- White cast iron
- Malleable cast iron
- Nodular cast iron (or) spheroidal graphite iron

Grey cast iron: Grey cast iron is soft and tougher than the white cast iron which is hard and brittle. The good mechanical properties of grey cast iron are due to the presence of particles of free state carbon or graphite, which separate out during slow cooling. Grey cast iron is of a weldable type. It contains 3 to 4% of carbon.

White cast iron: White cast iron is produced from pig iron by causing the casting to cool very rapidly. The rate of cooling is too rapid and this does not allow the carbon to separate from the iron carbide compound. Consequently the carbon found in white cast iron exists in the combined form. This type of cast iron is very hard and brittle and is not weldable and also not easily machinable.

Malleable cast iron: Malleable cast iron is obtained by annealing white cast iron over a prolonged period of time, and then allowing it to cool slowly. This heat treatment results in greater resistance to impact and shock.

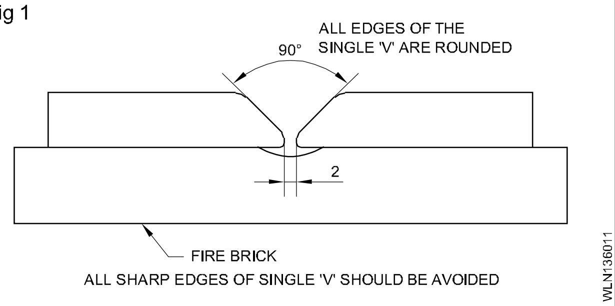
Nodular cast iron: It is also known as spheroidal graphite iron (SG iron). It is obtained by adding magnesium to the molten grey cast iron. The tensile strength and elongation of nodular iron is similar to that of steels which makes this iron a ductile material.

Properties of grey cast iron: Grey cast iron is mostly used in the manufacture of machine components. It has got good mechanical properties due to the free state carbon/graphite. The other constituents are silicon, sulphur, manganese and phosphorous. The grey cast iron has a much higher compressive strength than steel but has low ductility and tensile strength.

Since the carbon is in free graphite form it gives a grey colour to the fractured structure.

Method and types edge preparation: The edges of grey cast iron can be prepared by different methods such as chipping, grinding, machine and filing. The above methods are used according to the condition and type of the job. Usually it is required to weld, a cracked casting or a butt joint. Also the thickness of the casting to be welded or repaired will be 6 mm and above. So usually a single V butt joint is prepared as shown in Fig 1.

Fig 1



Method of cleaning

There are two methods used for cleaning cast iron jobs.

- Mechanical cleaning
- Chemical cleaning

Mechanical cleaning is mostly used to clean the surface of the cast iron jobs.

In this method grinding, filing and wire brushing tec. are done.

The chemical cleaning process is applied to remove oil, grease and any other substances which cannot be removed by mechanical cleaning.

Flame (strict neutral flame): Nozzle no. 10 is used in the blow pipe and a strict neutral flame should be adjusted. Care should be taken that there is not even the slightest trace of oxygen which would cause a weak weld through oxidation.

Filler rod: A 5 mm size round or square high (super) silicon cast iron filler rods containing 2.8 - 3.5 percentage silicon are used for cast iron welding. The weld metal by this rod is easily machinable. (The S-CI 1 as per IS 1278 - 1972).

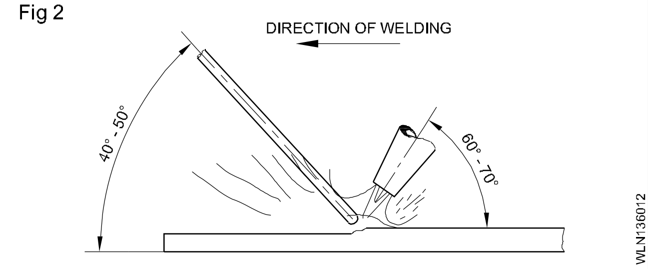
Flux: The flux should be of good quality to dissolve the oxides and prevent oxidation.

Cast iron flux is composed of borax, sodium carbonate, potassium carbonate, sodium nitrate and sodium bicarbonate. This is in a powder form.

Technique of cast iron welding: The welding operations should be performed on the preheated, dull red hot, cast iron piece. The preheating temperature for C.I welding varies from 200°C to 310°C.

The blowpipe angle should be 60° to 70° and the filler rod angle 40° to 50° to the line of weld. (Fig 2)

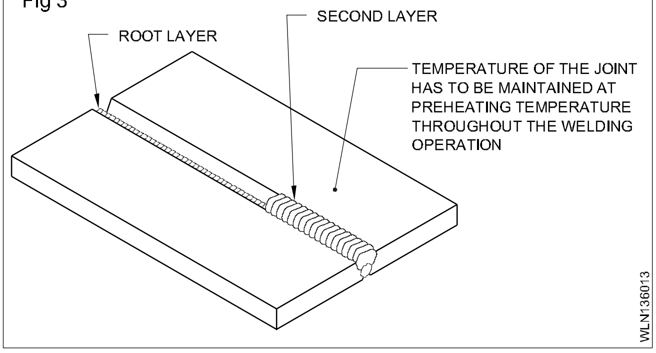
Fig 2



Using the leftward or forehead technique, the first layer should be complete by giving a slight weaving motion to the blowpipe but not to the filler rod. The hot rod end should be dipped into the powdered flux at intervals.

After the completion of the first layer, play the flame on the job so as to heat evenly and then deposit the second layer with a slight reinforcement of weld metal from the surface of the job. (Fig 3)

Fig 3



The technique of welding the second layer is the same as that for the first layer.

After completion of the second layer, play the flame again on the whole job for getting an even heat. This is called 'post heating'.

Then allow the job to cool slowly by covering with a heap of lime or ash or dry sand.

Selection of filler rod

Filler rod should be selected according to the:

- kind or type of metal to be welded, i.e. ferrous, non-ferrous, hard facing (Table 1).

  thickness of metal to be welded (including joint edge preparation) (Table 2)
- nature of joint to be made (i.e.), fusion welding or braze welding (non-fusion)
- welding technique to be used (leftward or rightward).

Table 1

Metals	**Filler rods**
Mild steel and wrought iron	Copper coated mild steel (C.C.M.S)
High carbon and alloy steel	High Carbon steel Silicon-manganese steel Wear-resisting alloy steel 3.5% Nickel steel
Stainless steel	Columbium stainless steel
Cast iron	Super silicon cast iron Ferro silicon cast iron Nicotectic cast iron
Copper and its alloys (brass, bronze)	Copper-silver alloy Silicon-brass, silicon-bronze Nickel bronze Manganese bronze
Aluminium and its alloys	Pure aluminium 5% Silicon aluminium alloy 10-13% Silicon aluminium alloy

Table 2

Thickness mm	**Edge preparation mm**	**Root gap**	**Dia. of filler rod mm**
0.8	Square	-	1.6
1.6	Square	2.4	1.6
2.4	Square	3.2	1.6
3.2	80° Vee	3.2	2.4
4.0	80° Vee	3.2	3.2
5.0	80° Vee	3.2	4.0

More the thickness of the metal welded, more the diameter of the filler rod used. Less the number of weld runs deposited, less the distortion and faster the welding.

Bronze welding of cast iron

Objectives: At the end of this lesson you shall be able to
- **describe the principle of bronze welding and its application**
- **explain the functions of bronze filler rods and flux**
- **describe the advantage and limitations of bronze welds of C.I**
- **state the various types and composition of bronze welding filler rods and function of each element in it.**

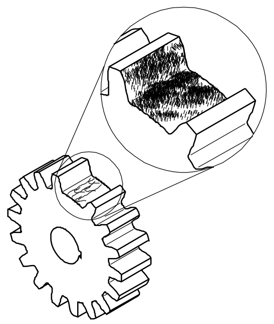
Bronze welding

Bronze welding is a process in which the joint is produced by heating the metal to suitable temperatures above 425° C (800°F) and depositing filler metal into a groove of the joint by using a non-ferrous filler rod having a melting point below that of the base metal.

When the filler metal is made of copper-zinc alloy, the process is referred to as bronze welding.

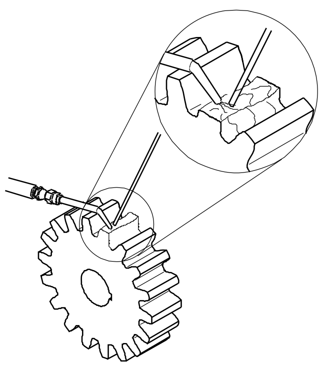
Applications of bronze welding: Bronze welding is particularly adoptable for joining or repairing such metals as cast iron, malleable iron, copper, brass and various dissimilar sections such as worn out of gear teeth. (Figs 1, 2, 3 & 4)

Fig 1



THE FIRST STAGE OF REPAIR-PREPARATION

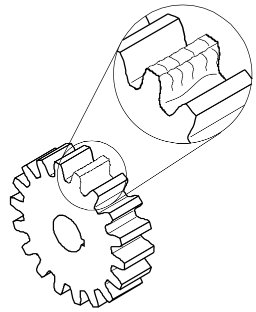
Fig 2



BRAZING

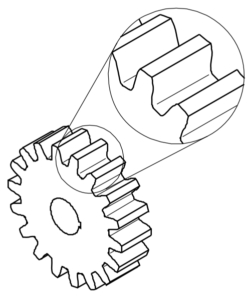
Characteristics of bronze filler rod: The main elements of a bronze filler rod used in bronze welding are copper and zinc which produce high tensile strength and ductility.

Fig 3



SLOW COOLING

Fig 4



FINISHED TOOTH

The elements like tin, manganese and silicon contained in the filler rod help to deoxidize the weld metal, decrease the tendency of zinc to fume, and increase the free-flowing action of the molten metal.

Hardness and wear-resistance is improved.

Flowing and wetting properties are improved.

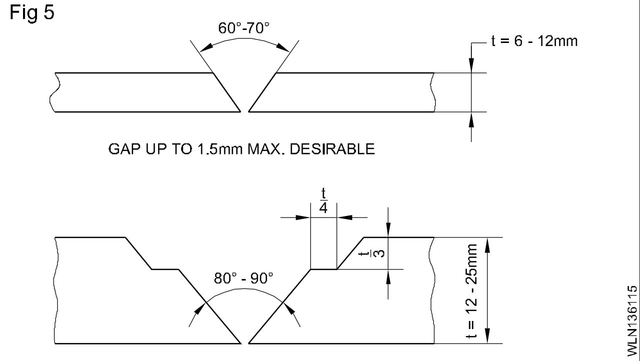
A bronze filler rod generally contains 60% copper and 40% zinc. A small percentage of other metals such as manganese, tin, nickel and silicon is added in the filler rod.

Importance of flux for bronze welding: Adhesion of the molten bronze to the base metal will take place only if the surface is chemically clean. Good surface cleaning action will be obtained by applying good quality flux which also prevents oxidation during welding.

Type of flame: A slightly oxidising flame is a suitable one. Since the melting point of zinc is 540°C and that of copper is 1083°C, before copper starts melting the zinc will evaporate as white fumes. Excess oxygen in the oxidising flame will convert zinc into zinc oxide and arrest the evaporation of zinc due to the higher melting pint of zinc oxide. While solidifying the flux will remove the oxide and maintain the bronze deposit.

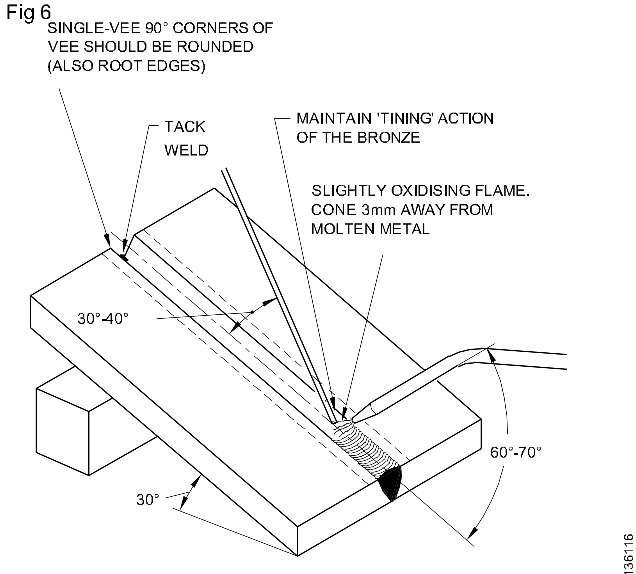
Welding technique: The edges are prepared as shown in Fig 5. All the edges of the joint are to be rounded off to avoid sharp edges.

Fig 5



Use leftward welding technique and keep the joint inclined at 30°. (Fig 6)

Fig 6



BRONZE WELDING CAST IRON

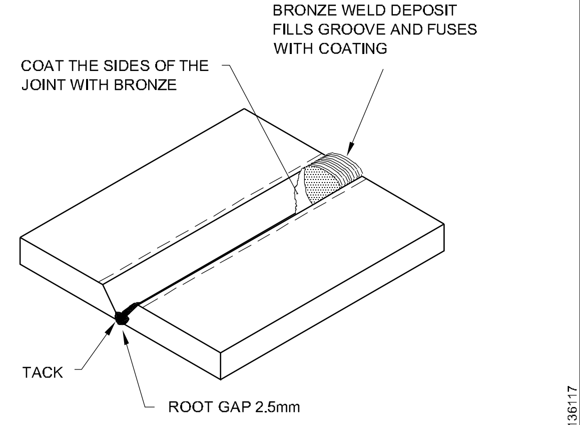
Ensure the job is preheated to 200°C to 300°C and the weld face is properly wetted/tinned before depositing the bronze filler metal. (Fig 7)

Use No. 10 nozzle on the blowpipe and 3 mm bronze filler rod dipped in powdered flux.

Cool the joint slowly by covering the job with asbestos powder or dry sand.

Remove the flux residue from the joint and clean the joint.

Fig 7



BRONZE WELDING CAST IRON

Advantages of bronze welding

Bronze welding is done at low temperature

Bronze welding can be done faster than fusion welding.

The base metal need not be heated to a molten condition. So there is less possibility of destroying the main characteristics of the base metal. This results in lower fuel consumption.

The low degree of heat in bronze welding reduces to a minimum the expansion and contraction forces and thereby reduces distortion.

Machining the welded portion is possible.

Limitations of bronze welding

Bronze welding is not useful to weld a metal that will be subjected to a high temperature in service, since bronze loses its strength when heated to (500°F) 260°C or more.

Bronze welding should not be used on steel parts that must withstand unusually high stresses.

Colour match will not be there with ferrous metals.

The filler metal costs more than the super silicon cast iron or steel filler metals used for full fusion welding.

In certain chemical processes, some materials that have almost no effect on cast iron but will react with the bronze filler metal.

Filler rods for bronze welding of cast iron

Types of filler rods

S-C4

S-C5

S-C6

S-C8

S-C9

S-C10

COMPOSITION OF EACH TYPE

S-C4

Copper 57 to 63%
Silicon 0.15 to 0.3%
Manganese 0.05 to 0.25%
Iron 0.1 to 0.5 %
Balance % zinc

Melting point of this filler rod is 870° to 900°C

S-C Fabrication : Welder - Exercise 1.1.01
Fabrication : Welder - Exercise 1.1.015

Tin 0.5% max
Manganese 0.5% max
Iron 0.5% max
Copper 45 to 53%
Melting point 970° to 980°C
Silicon 0.15 to 0.5%
Nickel 8 to 11%

S-C6

Copper 41 to 45%
Silicon 0.2 to 0.5%
Nickel 14 to 16%
Tin 1.00% max
Manganese 0.2 % max }
} Optional
Iron - 0.3% max }
Zinc balance

S-C8

Manganese bronze or high tensile brass.

S-C9

High nickel bronze (High tensile nickel brass)

S-C10

High nickel bronze (High tensile nickel brass)

FUNCTIONS OF EACH ELEMENT

Phosphorus

Deoxidiser

Tin

Improves the strength and corrosion resistance and wear resistance.

Nickel

Improves corrosion resistance, ductility.

Manganese

Deoxidiser, improves wear resistance.

Silicon

Improves fluidity.

Removes impurities.