LESSON PLAN

Date_______________ Trade:- Welder

Name_____________ Week No:- Twenty Two

Subject :- Cast iron –its properties and types.welding methods of cast iron.

Motivations:- in previous week we learned about Aluminum and its alloy, properties and weld ability, welding methods. Arc cutting and gauging.

PREPARATION: - Teaching Aids:-Chalk, Charts,

INTRODUCTION: - Cast iron is a group of iron-carbon alloys with a carbon content greater than 2%.[1] Its usefulness derives from its relatively low melting temperature. The alloy constituents affect its colour when fractured: white cast iron has carbideimpurities which allow cracks to pass straight through; grey cast iron has graphite flakes which deflect a passing crack and initiate countless new cracks as the material breaks; ductile cast iron which stops the crack from further progressing due to their spherical graphite "nodules".

PRESENTATION:-

Topic	Information Point	Spot Hint

Carbon (C) ranging from 1.8–4 wt%, and silicon (Si) 1–3 wt% are the main alloying elements of cast iron. Iron alloys with less carbon content are known as steel. While this technically makes the Fe–C–Si system ternary, the principle of cast iron solidification can be understood from the simpler binary iron–carbon phase diagram. Since the compositions of most cast irons are around the eutectic point (lowest liquid point) of the iron–carbon system, the melting temperatures usually range from 1,150 to 1,200 °C (2,100 to 2,190 °F), which is about 300 °C (540 °F) lower than the melting point of pure iron.

Cast iron tends to be brittle, except for malleable cast irons. With its relatively low melting point, good fluidity, castability, excellent machinability, resistance to deformation and wear resistance, cast irons have become an engineering material with a wide range of applications and are used in pipes, machines and automotive industry parts, such as cylinder heads (declining usage), cylinder blocks and gearbox cases (declining usage). It is resistant to destruction and weakening by oxidation (rust).

Production:-

Cast iron is made by re-melting pig iron, often along with substantial quantities of iron, steel, limestone, carbon (coke) and taking various steps to remove undesirable contaminants. Phosphorus and sulfur may be burnt out of the molten iron, but this also burns out the carbon, which must be replaced. Depending on the application, carbon and silicon content are adjusted to the desired levels, which may be anywhere from 2–3.5% and 1–3%, respectively. Other elements are then added to the melt before the final form is produced by casting.[citation needed]

Cast iron is sometimes melted in a special type of blast furnace known as a cupola, but in modern applications, it is more often melted in electric induction furnacesor electric arc furnaces.[4] After melting is complete, the molten cast iron is poured into a holding furnace or ladle.

Alloying elements

Cast iron's properties are changed by adding various alloying elements, or alloyants. Next to carbon, silicon is the most important alloyant because it forces carbon out of solution. A low percentage of silicon allows carbon to remain in solution forming iron carbide and the production of white cast iron. A high percentage of silicon forces carbon out of solution forming graphite and the production of grey cast iron. Other alloying agents, manganese, chromium, molybdenum, titanium and vanadium counteracts silicon, promotes the retention of carbon, and the formation of those carbides. Nickel and copper increase strength, and machinability, but do not change the amount of graphite formed. The carbon in the form of graphiteresults in a softer iron, reduces shrinkage, lowers strength, and decreases density. Sulfur, largely a contaminant when present, forms iron sulfide, which prevents the formation of graphite and increases hardness. The problem with sulfur is that it makes molten cast iron viscous, which causes defects. To counter the effects of sulfur, manganese is added because the two form into manganese sulfide instead of iron sulfide. The manganese sulfide is lighter than the melt so it tends to float out of the melt and into the slag. The amount of manganese required to neutralize sulfur is 1.7 × sulfur content + 0.3%. If more than this amount of manganese is added, then manganese carbide forms, which increases hardness and chilling, except in grey iron, where up to 1% of manganese increases strength and density.[5]

Nickel is one of the most common alloying elements because it refines the pearlite and graphite structure, improves toughness, and evens out hardness differences between section thicknesses. Chromium is added in small amounts to reduce free graphite, produce chill, and because it is a powerful carbide stabilizer; nickel is often added in conjunction. A small amount of tin can be added as a substitute for 0.5% chromium. Copper is added in the ladle or in the furnace, on the order of 0.5–2.5%, to decrease chill, refine graphite, and increase fluidity. Molybdenum is added on the order of 0.3–1% to increase chill and refine the graphite and pearlite structure; it is often added in conjunction with nickel, copper, and chromium to form high strength irons. Titanium is added as a degasser and deoxidizer, but it also increases fluidity. 0.15–0.5% vanadium is added to cast iron to stabilize cementite, increase hardness, and increase resistance to wear and heat. 0.1–0.3% zirconium helps to form graphite, deoxidize, and increase fluidity.[5]

In malleable iron melts, bismuth is added, on the scale of 0.002–0.01%, to increase how much silicon can be added. In white iron, boron is added to aid in the production of malleable iron; it also reduces the coarsening effect of bismuth.[5]

Grey cast iron[edit]

Main article: Grey iron

Grey cast iron is characterised by its graphitic microstructure, which causes fractures of the material to have a grey appearance. It is the most commonly used cast iron and the most widely used cast material based on weight. Most cast irons have a chemical composition of 2.5–4.0% carbon, 1–3% silicon, and the remainder iron. Grey cast iron has less tensile strength and shock resistance than steel, but its compressive strength is comparable to low- and medium-carbon steel. These mechanical properties are controlled by the size and shape of the graphite flakes present in the microstructure and can be characterised according to the guidelines given by the ASTM.[6]

White cast iron[edit]

White cast iron displays white fractured surfaces due to the presence of an iron carbide precipitate called cementite. With a lower silicon content (graphitizing agent) and faster cooling rate, the carbon in white cast iron precipitates out of the melt as the metastable phase cementite, Fe_3C, rather than graphite. The cementite which precipitates from the melt forms as relatively large particles. As the iron carbide precipitates out, it withdraws carbon from the original melt, moving the mixture toward one that is closer to eutectic, and the remaining phase is the lower iron-carbon austenite (which on cooling might transform to martensite). These eutectic carbides are much too large to provide the benefit of what is called precipitation hardening (as in some steels, where much smaller cementite precipitates might inhibit plastic deformation by impeding the movement of dislocations through the pure iron ferrite matrix). Rather, they increase the bulk hardness of the cast iron simply by virtue of their own very high hardness and their substantial volume fraction, such that the bulk hardness can be approximated by a rule of mixtures. In any case, they offer hardness at the expense of toughness. Since carbide makes up a large fraction of the material, white cast iron could reasonably be classified as a cermet. White iron is too brittle for use in many structural components, but with good hardness and abrasion resistance and relatively low cost, it finds use in such applications as the wear surfaces (impeller and volute) of slurry pumps, shell liners and lifter bars in ball mills and autogenous grinding mills, balls and rings in coal pulverisers, and the teeth of a backhoe's digging bucket (although cast medium-carbon martensitic steel is more common for this application).

It is difficult to cool thick castings fast enough to solidify the melt as white cast iron all the way through. However, rapid cooling can be used to solidify a shell of white cast iron, after which the remainder cools more slowly to form a core of grey cast iron. The resulting casting, called a *chilled casting*, has the benefits of a hard surface with a somewhat tougher interior.

High-chromium white iron alloys allow massive castings (for example, a 10-tonne impeller) to be sand cast, as the chromium reduces cooling rate required to produce carbides through the greater thicknesses of material. Chromium also produces carbides with impressive abrasion resistance.[citation needed] These high-chromium alloys attribute their superior hardness to the presence of chromium carbides. The main form of these carbides are the eutectic or primary M_7C_3carbides, where "M" represents iron or chromium and can vary depending on the alloy's composition. The eutectic carbides form as bundles of hollow hexagonal rods and grow perpendicular to the hexagonal basal plane. The hardness of these carbides are within the range of 1500-1800HV[7]

Malleable cast iron[edit]

Main article: Malleable iron

Malleable iron starts as a white iron casting that is then heat treated for a day or two at about 950 °C (1,740 °F) and then cooled over a day or two. As a result, the carbon in iron carbide transforms into graphite and ferrite plus carbon (austenite). The slow process allows the surface tension to form the graphite into spheroidal particles rather than flakes. Due to their lower aspect ratio, the spheroids are relatively short and far from one another, and have a lower cross section vis-a-vis a propagating crack or phonon. They also have blunt boundaries, as opposed to flakes, which alleviates the stress concentration problems found in grey cast iron. In general, the properties of malleable cast iron are more like those of mild steel. There is a limit to how large a part can be cast in malleable iron, as it is made from white cast iron.

Ductile cast iron[edit]

Main article: Ductile cast iron

Developed in 1948, *nodular* or *ductile cast iron* has its graphite in the form of very tiny nodules with the graphite in the form of concentric layers forming the nodules. As a result, the properties of ductile cast iron are that of a spongy steel without the stress concentration effects that flakes of graphite would produce. Tiny amounts of 0.02 to 0.1% magnesium, and only 0.02 to 0.04% cerium added to these alloys slow the growth of graphite precipitates by bonding to the edges of the graphite planes. Along with careful control of other elements and timing, this allows the carbon to separate as spheroidal particles as the material solidifies. The properties are similar to malleable iron, but parts can be cast with larger sections.

Comparative qualities of cast irons[8]

Name	Nominal composition	Form and condition	Yield strength	Tensile strength	Elongation [% (in	Hardness [Brinell	Uses
Grey cast iron	C 3.4, Si 1.8, Mn 0.5	Cast	—	50	0.5	260	Engine cylinder blocks, flywheels, gearbox
White cast iron	C 3.4, Si 0.7, Mn 0.6	Cast (as cast)	—	25	0	450	Bearing surfaces
Malleable iron (ASTM	C 2.5, Si 1.0, Mn 0.55	Cast (annealed)	33	52	12	130	Axle bearings, track wheels, automotive crankshafts
Ductile or nodular iron	C 3.4, P 0.1, Mn 0.4, Ni 1.0	Cast	53	70	18	170	Gears, camshafts, crankshafts
Ductile or nodular iron	—	cast (quench	108	135	5	310	—
Ni-hard type 2	C 2.7, Si 0.6, Mn 0.5, Ni 4.5	Sand-cast	—	55	—	550	High strength applications
Ni-resist type 2	C 3.0, Si 2.0, Mn 1.0	Cast	—	27	2	140	Resistance to heat and corrosion

A cast iron is an alloy of iron, carbon, and silicon, in which the amount of carbon is usually more than 1.7 percent and less than 4.5 percent. The overall weldability of cast iron is low and depends on the material type, complexity, thickness, casting complexity and need for machinability. Ductile and malleable irons have good weldability while grey cast iron and white cast iron are only weldable for small attachments.

The most widely used type of cast iron is known as gray iron. Gray iron has a variety of compositions, but is usually such that it is primarily perlite with many graphite flakes dispersed throughout.

There are also alloy cast irons which contain small amounts of chromium, nickel, molybdenum, copper, or other elements added to provide specific properties.

Another alloy iron is austenitic cast iron, which is modified by additions of nickel and other elements to reduce the transformation temperature so that the structure is austenitic at room or normal temperatures. Austenitic cast irons have a high degree of corrosion resistance.

In white cast iron, almost all the carbon is in the combined form. This provides a cast iron with higher hardness, which is used for abrasion resistance.

Malleable cast iron is made by giving white cast iron a special annealing heat treatment to change the structure of the carbon in the iron. The structure is changed to perlitic or ferritic, which increases its ductility.

Nodular iron and ductile cast iron are made by the addition of magnesium or aluminum which will either tie up the carbon in a combined state or will give the free carbon a spherical or nodular shape, rather than the normal flake shape in gray cast iron. This structure provides a greater degree of ductility or malleability of the casting.

A major factor contributing to the difficulty of welding cast iron is its lack of ductility. If cast irons are loaded beyond their yield points, they break rather than deform to any significant extent. Weld filler metal and part configuration should therefore be selected to minimize welding stresses.

MMA, flux cored arc, MIG, TIG and gas welding processes are normally used with nickel-based welding consumables to produce high-quality welds, but cast iron and steel electrodes can also produce satisfactory welds in certain alloys.

Weldability by Metal Type

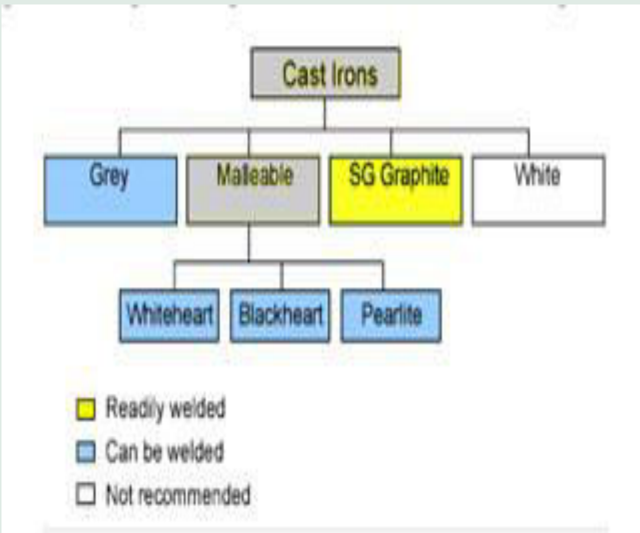


Table Credit:TWI

Applications

These types of metal are widely used in:

- agricultural equipment
- on machine tools as bases, brackets, and covers
- for pipe fittings
- cast iron pipe
- automobile engine blocks, heads, manifolds
- water preps
- repair defects in order to upgrade or salvage a casting before service

It is rarely used in structural work except for compression members. It is widely used in construction machinery for counterweights and in other applications for which weight is required.

Characteristics

Cast iron	Tensile strength (MPa)	Compressive strength (MPa)	Hardness (HB)	Elongation (%)	Toughness (J)
White	200–410	Not available	321–500	Very low	Very low
Malleable	276–724	1350–3600 (pearlitic and martensitic)	110–156 (ferritic) 149–321 (pearlitic and martensitic)	1–10	4–12 J @ 20°C
Grey	152–431	572–1293	156–302	<0.6	Very low
Ductile	345–827	359–920	143–302	2–20	16–27 J @ 20°C

- **Grey (Gray) or flake graphite**
  Where the graphite exists as branched interconnected flakes; this type of iron is relatively cheap and has poor mechanical properties. Grey irons are usually weldable with MMA(SMA), MIG (GMA) or FCAW as long as special consumables and procedures are used. Gray cast iron has low ductility and therefore will not expand or stretch to any considerable extent before breaking or cracking. Because of this characteristic, preheating is necessary when cast iron is welded by the oxyacetylene welding process. It can, however, be welded with the metal-arc process without preheating if the welding heat is carefully controlled. This can be accomplished by welding only short lengths of the joint at a time and allowing these sections to cool. By this procedure, the heat of welding is confined to a small area, and the danger of cracking the casting is eliminated. Large castings with complicated sections, such as motor blocks, can be welded without dismantling or preheating. Special electrodes designed for this purpose are usually desirable. Ductile cast irons, such as malleable iron, ductile iron, and nodular iron, can be successfully welded. For best results, these types of cast irons should be welded in the annealed condition.
- Nodular or spheroidal graphite (ductile iron)
  Where the graphite exists as graphite in a spheroidal form and the mechanical properties approach those of steel. Nodular irons are generally easier to weld than grey irons, but still require special consumables and procedures.
- Malleable CI
  Where the graphite exists as nodules or rosettes produced by heat treatment. Malleable irons have two main forms: blackheart malleable, which has similar weldability to nodular cast iron, and

whiteheart malleable, which is readily weldable with ferritic consumables provided care is taken to limit penetration.

- White
  A hard, brittle iron containing no free graphite. White irons are generally considered unweldable.
- Austenitic
  Where the graphite may exist in either flake or nodular form, resulting in good corrosion and heat resistance. Many grades of austenitic irons can be welded with special consumables and procedures.
- CI with High Silicon and Aluminum Content
  Where the graphite exists mainly as flakes and the material has good corrosion resistance. This alloy can be welded with special consumables and procedures.

Tips for Repairing a Crack in Cast Iron

Most problems have to do with the high carbon content. This results in cracking problems and thermal control issues. Cast irons have approximately 2 to 4% carbon.

Stick welding can be used to repair castings with several types of welds that are machine friendly:

- nickel 55 soft weld
- nickel 99 soft weld
- HTS-528 Brazing Rod (strongest brazing rod made for joining cast iron, with the convenience of a built in flux)

Nickel is a non-ferrous alloy that does not absorb any carbon making it a good choice for repair.

- Pre-heat any casting to avoid cracking. Control the pre-heating with a temple stick. When it melts it means that you can weld into the casting. Preheating a casting before weld repair can be very useful in controlling the cooling rate after welding. This is particularly important when repairing complex shapes since different thicknesses of material respond differently to the heat from the weld pool, which can result in damaging thermal stresses and distortion.
- Clean any joints that will be repaired or welded including grease and dirt. Use grinding or cleaning solvents.
- If after the repair porosity is a problem, grind the area back to the sound metal
- For repairs where there are casting imperfections, such as blow holes or cracks, all defective areas should be removed by cold chiseling, gouging or grinding. If gouging with a covered electrode or air-carbon arc, a heat affected zone will form around the gouged area. The casting should be preheated to 300°C before gouging to reduce the risk of cracking in this region. The groove should also be lightly ground to remove hardened material before depositing the repair, since graphite in this region may dissolve during gouging, increasing its sensitivity to cracking during subsequent welding. When removing cracks or linear defects, the ends of the crack should be blunted by drilling before gouging, to prevent further propagation during the preparation for repair. The true ends of the crack, which may be very

fine, should be located by dye penetrant or magnetic particle methods before drilling.

In video DC positive is used. Use the appropriate safety gear and eliminate fume exposure.

Cast Iron Welding Repair Preheating Is Recommended

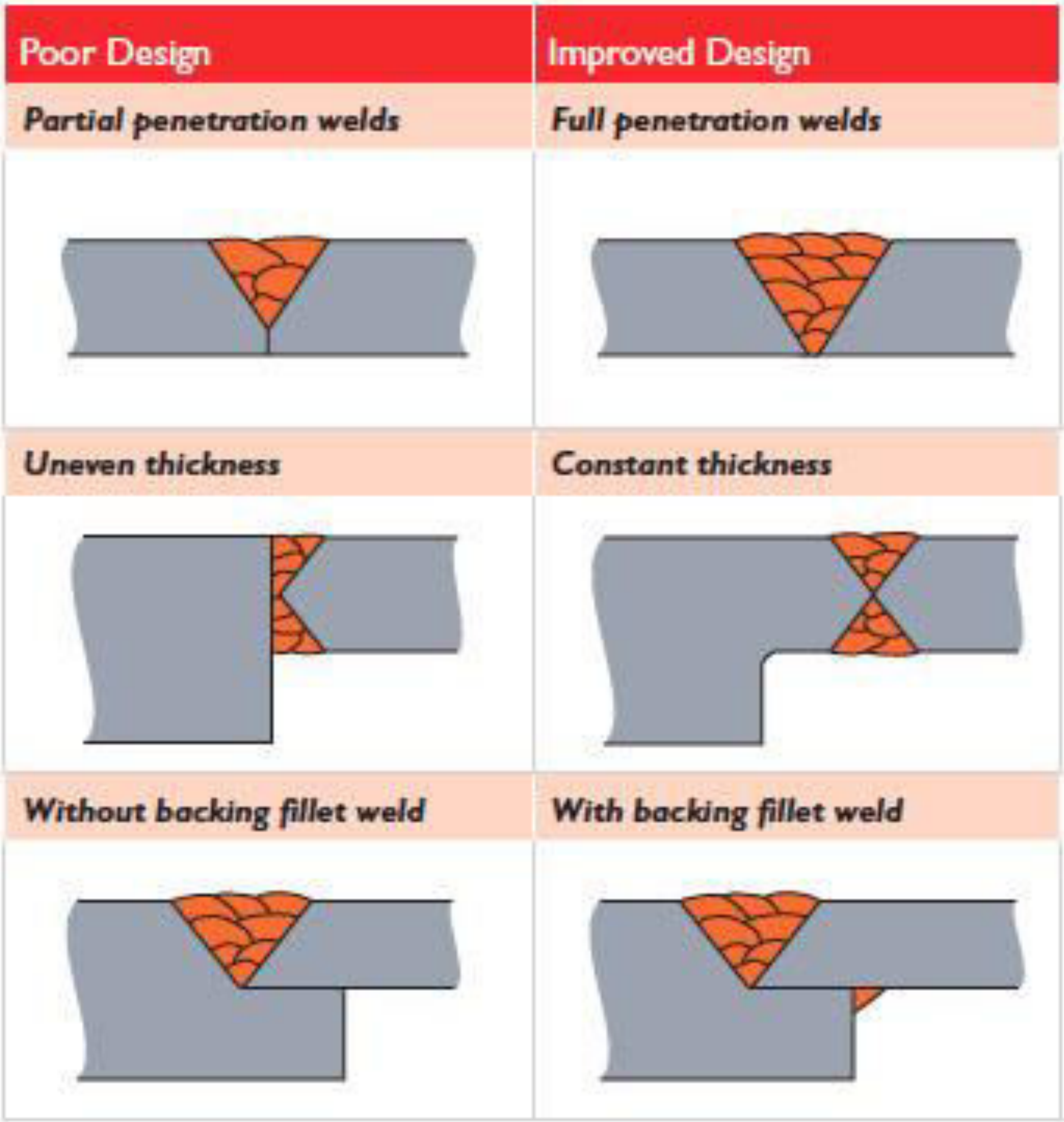
Benefits

Benefits as a welding metal:

- More fluid than steel (better castability)
- Lower melting point than steel
- Low cost material
- Can be shaped with sand casting
- Desirable Properties such as:
  - Damping capacity
  - Thermal conductivity
  - Ductility
  - Hardness
  - Strength

Design Recommendations

Poor vs Improved Cast Iron Weld Design



Modifications to Joint Design that Reduce Risk of Cracking When Welding Cast Iron

Welding Processes

Welding is used to salvage new iron castings, to repair castings that have failed in service, and to join castings to each other or to steel parts in manufacturing operations.

Table 7-19 shows the welding processes that can be used for welding cast, malleable, and nodular irons. The selection of the welding process and the welding filler metals depends on the type of weld properties desired and the service life that is expected. For example, when using the shielded metal arc welding process, different types of filler metal can be used. The filler metal will have an effect on the color match of the weld compared to the base material. The color match can be a determining factor, specifically in the salvage or repair of castings, where a difference of color would not be acceptable

No matter which of the welding processes is selected, certain preparatory steps should be made. It is important to determine the exact type of cast iron to be welded, whether it is gray cast iron or a malleable or ductile type. If exact information is not known, it is best to assume that it is gray cast iron with little or no ductility. In general, it is not recommended to weld repair gray iron castings that are subject to heating and cooling in normal service, especially when heating and cooling vary over a range of temperatures exceeding 400°F (204°C). Unless cast iron is used as the filler material, the weld metal and base metal may have different coefficients of expansion and contraction. This will contribute to internal stresses which cannot be withstood by gray cast iron. Repair of these types of castings can be made, but the reliability and service life on such repairs cannot be predicted with accuracy.

Welding Processes and Filler Metals for Cast Iron - Figure 7-19

Welding Process & Filler Metal Type	Filler Metal Spec	Filler Metal Type	Color Match	Machineable Deposit
SMAW (Stick)				
Cast iron	E-CI	Cast iron	Good	Yes
Copper-tin[2]	ECuSn A & C	Copper-5 or 8% tin	No	Yes
Copper-aluminum[2]	ECuAl-A2	Copper-10% aluminum	No	Yes
Mild steel	E-St	Mild steel	Fair	No
Nickel	ENi-CI	High nickel alloy	No	Yes
Nickel-iron	ENiFe-CI	50% Nickel plus iron	No	Yes
Nickel-copper	ENiCu-A & B	55 or 65% Ni + 40 or 30% W	No	Yes
Oxy Fuel Gas				
Cast iron	RCI & A & B	Cast iron-with minor alloys	Good	Yes
Copper zinc[2]	RCuZn B & C	58% Copper-zinc	No	Yes
Brazing[3]				
Copper zinc	RBCuZn A & D	Copper-zinc & copper-zinc-nickel	No	Yes
GMAW (MIG)				
Mild steel	E60S-3	Mild steel	Fair	No
Copper base[2]	ECuZn-C	Silicon bronze	No	Yes
Nickel-copper	ENiCu-B	High nickel	No	Yes
FCAW				
Mild steel	E70T-7	Mild steel	Fair	No
Nickel type	No spec	50% nickel plus iron	No	Yes

Welding Preparation

In preparing the casting for welding, it is necessary to remove all surface materials to completely clean the casting in the area of the weld. This means removing paint, grease, oil, and other foreign material from the weld zone. It is desirable to heat the weld area for a short time to remove entrapped gas from the weld zone of the base metal. The skin or high silicon surface should also be removed adjacent to the weld area on both the face and root side. The edges of a joint should be chipped out or ground to form a 60° angle or bevel. Where grooves are involved, a V groove from a 60-90° included angle should be used. The V should extend approximately 1/8 in. (3.2 mm) from the bottom of the crack. A small hole should be drilled at each end of the crack to keep it from spreading. Complete penetration welds should always be used, since a crack or defect not completely removed may quickly reappear under service conditions. Preheating is desirable for welding cast irons with any of the welding processes. It can be reduced when using extremely ductile filler metal. Preheating will reduce the thermal gradient between the weld and the remainder of the cast iron. Preheat temperatures should be related to the welding process, the filler metal type, the mass, and the complexity of the casting. Preheating can be done by any of the normal methods. Torch heating is normally used for relatively small castings weighing 30.0 lb (13.6 kg) or less. Larger parts may be furnace preheated, and in some cases, temporary furnaces are built around the part rather than taking the part to a furnace. In this way, the parts can be maintained at a high interpass temperature in the temporary furnace during welding. Preheating should be general, since it helps to improve the ductility of the material and will spread shrinkage stresses over a large area to avoid critical stresses at any one point. Preheating tends to help soften the area adjacent to the weld; it assists in degassing the casting, and this in turn reduces the possibility of porosity of the deposited weld metal; and it increases welding speed.

Slow cooling or post heating improves the machinability of the heat-affected zone in the cast iron adjacent to the weld. The post cooling should be as slow as possible. This can be done by covering the casting with insulating materials to keep the air or breezes from it.

Electrodes

Cast iron can be welded with a coated steel electrode, but this method should be used as an emergency measure only. When using a steel electrode, the contraction of the steel weld metal, the carbon picked up from the cast iron by the weld metal, and the hardness of the weld metal caused by rapid cooling must be considered. Steel shrinks more than cast iron when ceded from a molten to a solid state. When a steel electrode is used, this uneven shrinkage will cause strains at the joint after welding. When a large quantity of filler metal is applied to the joint, the cast iron may crack just back of the line of fusion unless preventive steps are taken. To overcome these difficulties, the prepared joint should be welded by depositing the weld metal in short string beads, 0.75 to 1.0 in. long (19.0 to 25.4 mm). These are made intermittently and, in some cases, by the backstep and skip procedure. To avoid hard spots, the arc should be struck in the V, and not on the surface of the base metal. Each short length of

weld metal applied to the joint should be lightly peened while hot with a small ball peen hammer, and allowed to cool before additional weld metal is applied. The peening action forges the metal and relieves the cooling strains.
The electrodes used should be 1/8 in. (3.2 mm) in diameter to prevent excessive welding heat. Welding should be done with reverse polarity. Weaving of the electrode should be held to a minimum. Each weld metal deposit should be thoroughly cleaned before additional metal is added.
Cast iron electrodes must be used where subsequent machining of the welded joint is required. Stainless steel electrodes are used when machining of the weld is not required. The procedure for making welds with these electrodes is the same as that outlined for welding with mild steel electrodes. Stainless steel electrodes provide excellent fusion between the filler and base metals. Great care must be taken to avoid cracking in the weld, contracts approximately 50 percent more than because stainless steel expands and mild steel in equal changes of temperature.

Arc Welding

The shielded metal arc welding process can be utilized for welding cast iron. There are four types of filler metals that may be used: cast iron covered electrodes; covered copper base alloy electrodes; covered nickel base alloy electrodes; and mild steel covered electrodes. There are reasons for using each of the different specific types of electrodes, which include the machinability of the deposit, the color match of the deposit, the strength of the deposit, and the ductility of the final weld.
When arc welding with the cast iron electrodes (ECI), preheat to between 250 and 800°F (121 and 425°C), depending on the size and complexity of the casting and the need to machine the deposit and adjacent areas. The higher degree of heating, the easier it will be to machine the weld deposit. In general, it is best to use small-size electrodes and a relatively 1ow current setting. A medium arc length should be used, and, if at all possible, welding should be done in the flat position. Wandering or skip welding procedure should be used, and peening will help reduce stresses and will minimize distortion. Slow cooling after welding is recommended. These electrodes provide an excellent color match cm gray iron. The strength of the weld will equal the strength of the base metal. There are two types of copper-base electrodes: the copper tin alloy and the copper aluminum types. The copper zinc alloys cannot be used for arc welding electrodes because of the low boiling temperature of zinc. Zinc will volatilize in the arc and will cause weld metal porosity.
When the copper base electrodes are used, a preheat of 250 to 400°F (121 to 204°C) is recommended. Small electrodes and low current should be used. The arc should be directed against the deposited metal or puddle to avoid penetration and mixing the base metal with the weld metal. Slow cooling is recommended after welding. The copper-base electrodes do not provide a good color match.
There are three types of nickel electrodes used for welding cast iron. These electrodes can be used without preheat; however, heating to 100°F (38°C) is recommended. These electrodes can be used in all positions; however, the flat position is recommended. The welding slag should be removed between passes. The nickel and nickel iron deposits are extremely ductile

and will not become brittle with the carbon pickup. The hardness of the heat-affected zone can be minimized by reducing penetration into the cast iron base metal. The technique mentioned above, playing the arc on the puddle rather than on the base metal, will help minimize dilution. Slow cooling and, if necessary, post heating will improve machinability of the heat-affected zone. The nickel-base electrodes do not provide a close color match.

Copper nickel type electrodes cane in two grades. Either of these electrodes can be used in the same manner as the nickel or nickel iron electrode with about the same technique and results. The deposits of these electrodes do not provide a color match.

Mild steel electrodes are not recommended for welding cast iron if the deposit is to be machined. The mild steel deposit will pick up sufficient carbon to make a high-carbon deposit, which is impossible to machine. Additionally, the mild steel deposit will have a reduced level of ductility as a result of increased carbon content. This type of electrode should be used only for small repairs and should not be used when machining is required. Minimum preheat is possible for small repair jobs. Small electrodes at low current are recommended to minimize dilution and to avoid the concentration of shrinkage stresses. Short welds using a wandering sequence should be used, and the weld should be peened as quickly as possible after welding. The mild steel electrode deposit provides a fair color match.

Carbon-arc Welding of Cast Iron

Iron castings may be welded with a carbon arc, a cast iron rod, and a cast iron welding flux. The joint should be preheated by moving the carbon electrodes along the surface. This prevents too-rapid cooling after welding. The molten puddle of metal can be worked with the carbon electrode so as to move any slag or oxides that are formed to the surface. Welds made with the carbon arc cool more slowly and are not as hard as those made with the metal arc and a cast iron electrode. The welds are machinable.

Oxyfuel Gas Welding

The oxyfuel gas process is often used for welding cast iron. Most of the fuel gases can be used. The flame should be neutral to slightly reducing. Flux should be used. Two types of filler metals are available: the cast iron rods and the copper zinc rods. Welds made with the proper cast iron electrode will be as strong as the base metal. Good color match is provided by all of these welding reds. The optimum welding procedure should be used with regard to joint preparation, preheat, and post heat. The copper zinc rods produce braze welds. There are two classifications: a manganese bronze and a low-fuming bronze. The deposited bronze has relatively high ductility but will not provide a color match.

Brazing and Braze Welding

Brazing is used for joining cast iron to cast iron and steels. In these cases, the joint design must be selected for brazing so that capillary attraction causes the filler metal to flow between closely fitting parts. The torch method is normally used. In addition, the carbon arc, the twin carbon arc, the gas tungsten arc, and the plasma arc can all be used as sources of heat. Two brazing filler metal alloys are normally used; both are copper zinc alloys. Braze welding can also be used to join cast iron. In braze welding, the filler metal is not drawn into the joint by capillary attraction. This is sometimes called bronze welding. The filler material having a liquidous above 850°F (454°C) should be used. Braze welding will not provide a color match.

Braze welding can also be accomplished by the shielded metal arc and the gas metal arc welding processes. High temperature preheating is not usually required for braze welding unless the part is extremely heavy or complex in geometry. The bronze weld metal deposit has extremely high ductility, which compensates for the lack of ductility of the cast iron. The heat of the arc is sufficient to bring the surface of the cast iron up to a temperature at which the copper base filler metal alloy will make a bond to the cast iron. Since there is little or no intermixing of the materials, the zone adjacent to the weld in the base metal is not appreciably hardened. The weld and adjacent area are machinable after the weld is completed. In general, a 200°F (93°C) preheat is sufficient for most application. The cooling rate is not extremely critical and a stress relief heat treatment is not usually required. This type of welding is commonly used for repair welding of automotive parts, agricultural implement parts, and even automotive engine blocks and heads. It can only be used when the absence of color match is not objectionable.

Gas Metal Arc Welding

The gas metal arc welding process can be used for making welds between malleable iron and carbon steels. Several types of electrode wires can be used, including:

- Mild steel using 75% argon + 25% CO_2 for shielding.
- Nickel copper using 100% argon for shielding.
- Silicon bronze using 50% argon + 50% helium for shielding.

In all cases, small diameter electrode wire should be used at low current. With the mild steel electrode wire, the Argon-CO_2 shielding gas mixture issued to minimize penetration. In the case of the nickel base filler metal and the Copper base filler metal, the deposited filler metal is extremely ductile. The mild steel provides a fair color match. A higher preheat is usually required to reduce residual stresses and cracking tendencies.

Flux-cored Arc Welding

This process has recently been used for welding cast irons. The more successful application has been using a nickel base flux-cored wire. This electrode wire is normally operated with CO_2 shielding gas, but when lower mechanical properties are not objectionable, it can be operated without external shielding gas. The minimum preheat temperatures can be used. The technique should minimize penetration into the cast iron base metal. Post heating is normally not required. A color match is not obtained.

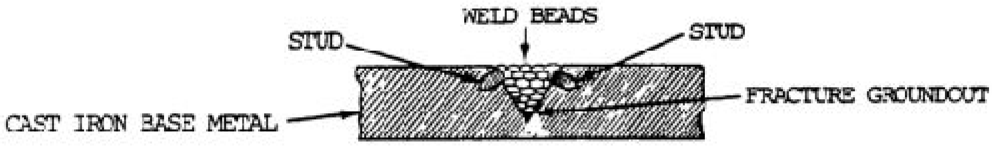
Other Processes

Other welding processes can be used for cast iron. Thermit welding has been used for repairing certain types of cast iron machine tool parts. Soldering can be used for joining cast iron, and is sometimes used for repairing small defects in small castings. Flash welding can also be used for welding cast iron.

Welding Techniques

Studding

Studding Method for Cast Iron Repair



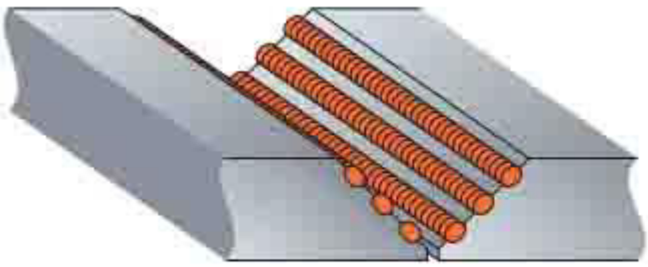
Cracks in large castings are sometimes repaired by studding (figure 7-10). In this process, the fracture is removed by grinding a V groove. Holes are drilled and tapped at an angle on each side of the groove, and studs are screwed into these holes for a distance equal to the diameter of the studs, with the upper ends projecting approximately 1/4 in. (6.4 mm) above the cast iron surface. The studs should be seal welded in place by one or two beads around each stud, and then tied together by weld metal beads. Welds should be made in short lengths, and each length peened while hot to prevent high stresses or cracking upon cooling. Each bead should be allowed to cool and be thoroughly cleaned before additional metal is deposited. If the studding method cannot be applied, the edges of the joint should be chipped out or machined with a round-nosed tool to form a U groove into which the weld metal should be deposited.

Joint Design Modification

It is preferred that a full penetration weld is used over one where there is partial penetration. Welds that have varying thickness can result in uneven contraction stresses and uneven expansion during the welding cycle. Changing welding designs to locate welds in an area where there is constant thickness can be beneficial. Another tip is to use a backing fillet weld to support stressed areas.

Groove Face Grooving

Cast Iron Groove Face Grooving



Gouging or grinding grooves into the surface area of a prepared weld groove, followed by using a weld bead to fill the grooves, before filling the whole joint is sometimes a preferred method (see illustration below). This approach lowers cracking risks by deflecting the crack path. Beads that are in contact with the casting are deposited first, when the stress heat affected zone and fusion line are at a low.

Peening (Hammering)

Peening or hammering using a 13-19mm ball-peen hammer applied to a deformable weld bead, putting it into a state of compressive stress, the tensile stresses caused be thermal contraction can be opposed, thus reducing the risk of cracking in and around the weld.

When the hammer is applied manually, it strikes a moderate blow perpendicular to the weld surface.

The process requires a ductile weld metal. Nickel fillers are used, particularly when working with gray cast iron. Peening is performed at higher temperatures while the metal is soft.

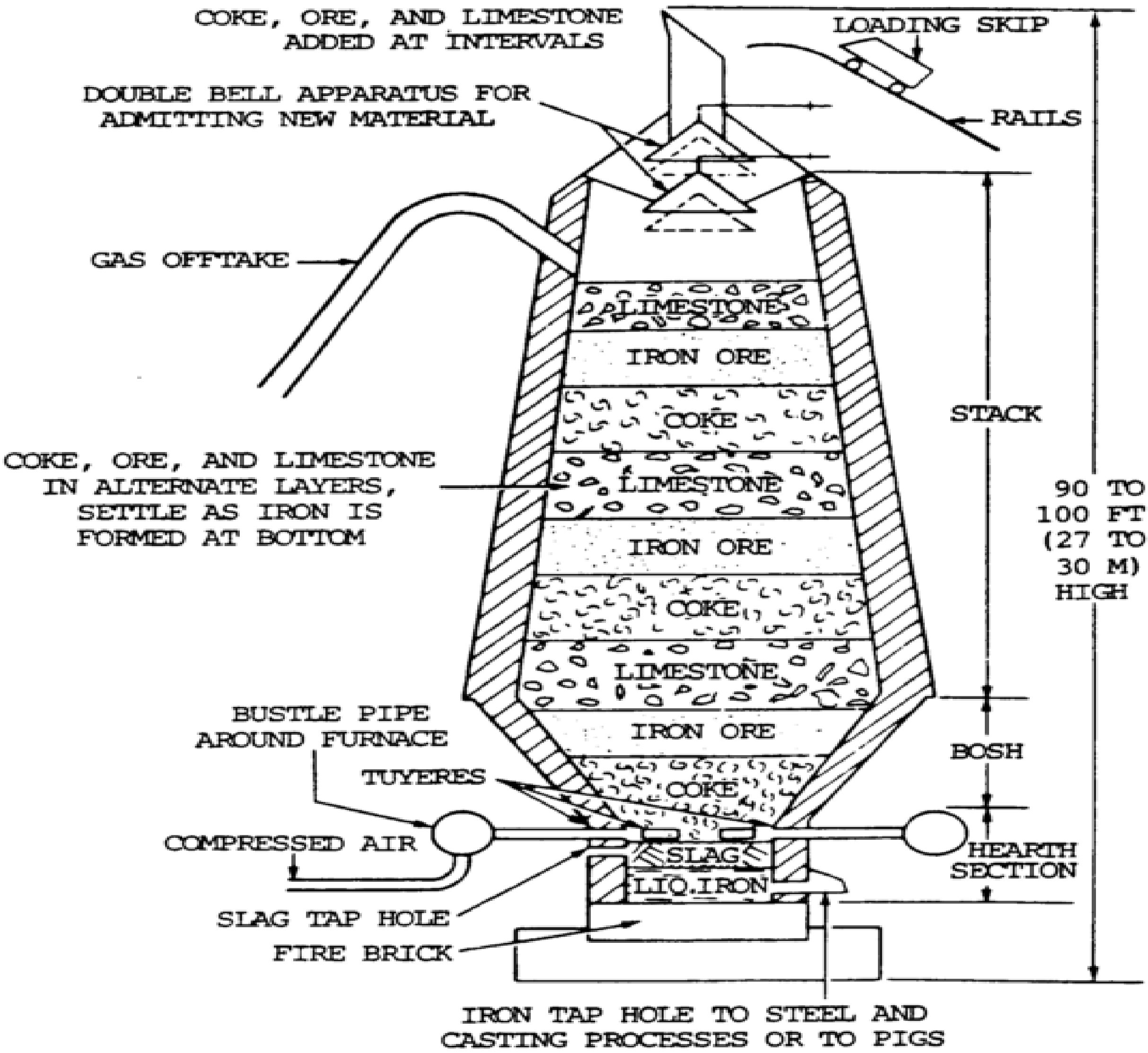


Figure 7-5. Blast furnace.

Questions:-

1. What is Cast Iron?
2. Right Cast iron welding process.
3. Write all types of cast iron.

Assignment:- Cast iron –its properties and types.welding methods of cast iron.

Checked by………………………….. Instructor……………..