

# RESEARCH OF CAST IRON IN ACIDIC MEDIUM IN THE INDUSTRIAL FIELD AS COMPONENTS IN ACID PICKLING

\*Bijender Singh, #Dr. Manoj Kumar Agarwal

#Accurate Institute of Management & Technology, Noida

## ABSTRACT

Cast iron is the common metallic material being used for numerous applications in a variety of industries as well as in daily life. Cast iron is commonly used in fabrication of reaction vessels, storage tanks by industries, sinks, hose pipe lines, automobiles, etc. because of its low cost and reasonably good strength. Hydrochloric acid is the most difficult to handle from the standpoints of corrosion. Extreme care is required in the selection of materials to handle the acid by itself, even in relatively dilute concentrations or in process solutions containing appreciable amounts of hydrochloric acid. Most of severe corrosion problems encountered involve the mineral acids or their derivatives. Cast iron corrodes when it comes in contact with aggressive environment. Corrosion inhibitors are added to the corroding medium in small concentration to control the corrosion rate of metals and alloys. In general, any phase constituent whose presence is not essential to the occurrence of an electrochemical process, but leads to a retardation of this process by modifying the surface state of the metallic material will be called an inhibitor. In a sense, an inhibitor can be considered as a retarding catalyst. Acid corrosion inhibitors find wide application in the industrial fields as components in acid pickling, acid cleaning, oil well acidizing, acid desalting etc. Most of the efficient inhibitors used in industry are organic compounds having multiple bonds in their molecule which are adsorbed on metal surface. There are numerous inhibitor types and compositions. Most inhibitor has been developed by empirical experimentation and many inhibitors are proprietary in nature and thus their composition is not disclosed.

## INTRODUCTION TO CAST IRON

Cast iron is derived from pig iron, and while it usually refers to gray iron, it also identifies a large group of ferrous alloys which solidify with a eutectic. The color of a fractured surface can be used to identify an alloy. White cast iron is named after its white surface when fractured, due to its carbide impurities which allow cracks to pass straight through. Grey cast iron is named after its grey fractured surface, which occurs because the graphitic flakes deflect a passing crack and initiate countless new cracks as the material breaks.

Carbon (C) and silicon (Si) are the main alloying elements, with the amount ranging from 2.1 to 4 wt% and 1 to 3 wt%, respectively. Iron alloys with less carbon content are known as steel. While this technically makes these base alloys ternary Fe-C-Si alloys, the principle of cast iron solidification is understood from the binary iron-carbon phase diagram. Since the compositions of most cast irons are around the eutectic point of the iron-carbon system, the melting temperatures closely correlate, usually ranging from 1,150 to 1,200 °C (2,102 to 2,192 °F), which is about 300 °C (572 °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 scrap iron, scrap steel, lime stone, carbon (coke) and taking various steps to remove undesirable contaminants. Phosphorus and sulphur 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 to 3.5% and 1 to 3% respectively. Other elements are then added to the melt before the final form is produced by casting. Iron is sometimes melted in a special type of blast furnace known as a cupola, but more often melted in electric induction furnaces or electric arc furnaces. After melting is complete, the molten iron is poured into a holding furnace or ladle.

## TYPES OF IRON'S 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. Instead the carbon forms graphite which results in a softer iron, reduces shrinkage, lowers strength, and decreases density. Sulfur, when added, forms iron sulfide, which prevents the formation of graphite and increases hardness. The problem with sulfur is that it makes molten cast iron sluggish, which causes short run 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  $1.7 \times \text{sulfur content} + 0.3\%$ .

Nickel is one of the most common alloyants 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 the ladle 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 to 2.5%, to decrease chill, refine graphite, and increase fluidity. Molybdenum is added on the order of 0.3 to 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 to 0.5% vanadium are added to cast iron to stabilize cementite, increase hardness, and increase resistance to wear and heat. 0.1 to 0.3% zirconium helps to form graphite, deoxidize, and increase fluidity.

In malleable iron melts, bismuth is added, on the scale of 0.002 to 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.

### Grey cast iron

Grey cast iron is characterized 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 to 4.0% carbon, 1 to 3% silicon, and the remainder is 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.

### White cast iron

It is the iron that displays white fractured surface due to the presence of cementite. With a lower silicon content and faster cooling, 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, usually in a eutectic mixture, where the other phase is austenite (which on cooling might transform to martensite). These eutectic carbides are much too large to provide precipitation hardening (as in some steels, where cementite precipitates might inhibit plastic deformation by impeding the movement of dislocations through the 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 and a somewhat tougher interior.

High-chromium white iron alloys allow massive castings (for example, a 10-tonne impeller) to be sand cast, i.e., a high cooling rate is not required, as well as providing impressive abrasion resistance.

### Malleable cast iron

Malleable iron starts as a white iron casting that is then heat treated at about 900 °C (1,650 °F). Graphite separates out much more slowly in this case, so that surface tension has time to form it into spheroidal particles rather than flakes. Due to their lower aspect ratio, spheroids are relatively short and far from one another, and have a lower cross section vis-à-vis a propagating crack or phonon. They also have blunt boundaries, as opposed to flakes, which alleviates the stress concentration problems faced by grey cast iron. In general, the properties of malleable cast iron are more like mild steel. There is a limit to how large a part can be cast in malleable iron, since it is made from white cast iron.

### Ductile cast iron

A more recent development is nodular or ductile cast iron. Tiny amounts of magnesium or cerium added to these alloys slow down 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.

## REVIEW OF LITERATURE

Hydrochloric acid is the most difficult of the common acids to handle from the standpoint of corrosion and materials of construction. Extreme care is required in the selection of materials to handle the acid by itself, even in relatively dilute concentrations, or in process solution containing appreciable amount of hydrochloric acid. Hydrochloric is very corrosive to the metal steel. When aeration or oxidizing agents are also present, corrosive conditions may be very rugged. Cast iron is not recommended for hydrochloric acid service. Rapid corrosion occurs at pH 4 or 5 or below, particularly if appreciable solution velocities are involved. Inhibitors are required when cast iron equipment is cleaned by pickling with hydrochloric acid. The inhibiting action exercised by organic compounds as the dissolution of metallic materials is normally attributed to interactions by adsorption between the inhibitor and the metal surface, although some authors consider that this phenomenon forms only the first stage of the inhibition process proper. The species that are adsorbed physically by means of electrostatic or Vander Waal's interacted rapidly with the electrode but are easily removed from the surface by immersion of the cast iron in a solution free from any inhibitor. The possibility of correlating structural characteristics with the inhibitor properties of organic substance is justified by the fact that the metal inhibitor. Interactions are based on chemisorptions. The electron density of the organic function that can be defined as the reaction centre for the establishment of the adsorption bond is then obviously important since it is possible to assume a bond of the Lewis acid- base type, generally with the inhibitor as the electron donor and the metal as the electron acceptor. The strength of this bond depends on the characteristics of both the adsorbent and the adsorbate. Most organic inhibitor is compounds with at least one polar function having atoms of nitrogen, sulfur and oxygen. In general, the polar function is regarded as the reaction centre for the establishment of the chemisorptions process. The adsorption bond strength is determined by the electron density of the atom acting as the reaction centre and by the polarizability of the function. The effectiveness of the function atoms with respect to the adsorption process, when the stabilities of the compounds are equal, can be taken as being in the following sequence Sulfur > Nitrogen > Oxygen. The idea of electron density acquires particular importance in aromatic or heterocyclic inhibitors whom structure may be affected the introduction of substituents in different positions of the rings. The availability of electron pairs for the formation of chemisorption bonds can thus be altered by regular and systematic variation of the molecular structure. The availability of electron pairs for the formation of chemisorptions bonds can thus be altered by regular and systematic variation of the molecular structure.

## RESEARCH METHODOLOGY

The proposed research work is scientific research and totally base on lab work as well as in field too. The said research related information collected from various article journal and books of science in field of chemistry and industrial chemistry. The research design related with chapter plan of study. The studding process is an extremely complex process due to the fact that one requires a lot of skill for this method. The first step is to drill and tap holes on the surface that has beveled. The next step is to put in steel studs and weld them into the surface. The steel studs will help in covering the entire surface into the location where the surface has cracked. The welded deposit can be further used to make reinforcement over the crack.

It is recommended that one resorts to the non-preheating cast iron welding procedure for domestic purposes. While welding cast iron to steel the preheating procedure proves to be highly effective.

## SCOPE OF STUDY

Out of various alloys of iron, cast iron is the common metallic material being used for numerous applications in a variety of industries as well as in daily life. Cast iron corrodes when it comes in contact with aggressive environment but its use is still the most reasonably because of very low cost, easy availability and good mechanical strength. Corrosion causes loss of metals, leakage in heat exchangers pipe lines, thinning of metal sheet, loss in mechanical strength, rupture of metal sheet etc. As the corrosion inhibitors protect the metal surface through adsorption, the surfactants which can be assumed to have better adsorption capability were used as corrosion inhibitor in the present work. Surfactants with high molecular weights alkyl groups were used as inhibitors. In the present work the corrosion of cast iron in 1M Hydrochloric acid solution by these inhibitors were studied. Corrosion rate and percentage inhibitor efficiency were found out for all the corrosion inhibitors at different concentrations and at various temperatures. Inhibitors are added to system, which in turn add to the cost of operations. So, it is necessary to find inhibitor, which reduces the cost while keeping the problem of corrosion under control.

## OBJECTIVE

The main objectives of the present work were:-

- To study the corrosion rate of cast iron in various concentration of inhibitor in 1M hydrochloric acid solutions at different temperatures using weight loss technique. To evaluate various corrosion parameters like weight loss, corrosion rate, percentage inhibition efficiency etc.
- To study corrosion behaviour of cast iron in 1M Hydrochloric acid solution in detail in the presence of various surfactants added at different temperatures and concentrations of the inhibitors.
- To find optimum concentration of corrosion inhibitors to achieve maximum inhibition efficiency.
- To study the adsorption Kinetics for all the inhibitors to assess the type of adsorption occurring on the metal surface.



## CONCLUSION

A limited number of compression experiments were performed on ductile cast iron, which is used for the fabrication of thick-walled canister inserts. This test programme was organized to complement an extensive series of tensile experiments, primarily because compressive stresses prevail under deep disposal conditions. The main conclusions from this work are as follows:

- a) The ductile cast iron showed more pronounced strain hardening in compression than observed under tensile conditions.
- b) On the other hand compressive Young's Modulus and proof stress figures were comparable to the equivalent tensile values.
- c) Increasing the temperature to 100 °C resulted in a significant shift downwards of a compression curve.
- d) The test specimens did not show any low ductility failure (i.e. below 10%), even if there was evidence of (micro) cracking inside the test specimens.

In industrial applications, parts with diverse properties are used to compliance the needs. Among different kinds of metals coatings, conversion coatings can be called divided in two groups: natural and chemical conversion coatings. Natural conversion coatings called oxide coatings are naturally formed on metal substrates, while chemical conversion coatings are oxide coatings that are artificially formed on metal substrates by means of proper chemical bathes. From different kinds of chemical conversion coatings, oxalate, phosphate, chromate and oxide conversion coatings, can be named. Due the important effects of blackening bath boiling point on coating quality, the precious control of coating temperature is very important. It was found that temperature between 135oC to 140oC is required to achieve smooth, deep and jet black finish. Generally, conventional blackening bathes offer the use of sodium salts but this research showed that using of blackening bath containing potassium salts will lead to higher quality and uniform coating. The application of blackening bath containing potassium salts, in addition to preventing negative effects of some elements on the cast Iron blackening, it also prevents decreasing the efficiency and lifetime of the bath. In order to blacken cast Iron surface it is necessary to pickle the metal surface with an etching solution such as one containing hydrochloric acid. After this step, cast Iron is in a condition very susceptible to blackening. Results of this research showed that acid pickling before coating step have important effects on improvement of blackening process. Some of researches confirm this result. Coating quality of blackened parts in potassium containing coating bath, is higher than blackened parts in sodium containing coating bath. In some cases, corrosion resistance of this parts as determined by salt spray exposure test has remarkable increase and yield up to 150 hours.

CTAB acts as a good inhibitor for the corrosion of C-steel in 1M and 2M HCl solutions, and the maximum inhibition efficiency is about 87% in 2M HCl solution. The inhibition efficiency values increase with the inhibitor dose, but decrease with the temperature. The corrosion rate of C-steel in the presence and absence of CTAB acts as a function of immersion time. Increasing the immersion time resulted in increasing the inhibition efficiency. The weight loss and the electrochemical polarization studies are in good agreement. CTAB acts as a mixed-type inhibitor in 1M and 2M HCl. The adsorption of CTAB on C-steel surface obeys the Langmuir adsorption isotherm. The value of both the

adsorptive rate constant  $K$  and the apparent activation energy  $E_a$  are increases in the presence of CTAB in HCl solutions. The inhibitive mechanism was proposed.

## **FUTURE SCOPE**

The second step in crystallisation is crystal growth. The crystal growth is important for the final crystal size distribution (CSD). The crystal size distribution often plays a role in products produced by industrial crystallisation. According to Perry, crystal growth is a layer by layer process. In many cases crystals with the same geometry have the same growth rate. Crystal growth will not be discussed more in detail in this report.

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