Corrosion of Cast Irons - Corrosion of Cast Carbon and Low-Alloy Steels

Corrosion of Cast Irons

Cast iron is a standard term which is used for a large family of alloys of ferrous materials. Cast iron is mainly alloy of iron (Fe) which contains higher than 2 % of carbon (C) and more than 1 % of silicon (Si). Low cost of raw materials and relative ease of production make cast iron the last cost engineering material. Cast iron can be cast into intricate shapes since it has excellent fluidity and comparatively low melting point. It can also be alloyed for improvement of corrosion resistance and strength. With suitable alloying, the corrosion resistance of cast iron can equal to or exceed that of stainless steel and nickel (Ni) based alloy. Since outstanding properties are obtained with this low cost engineering material, cast iron finds extensive use in atmospheres which need good corrosion resistance. Services in which cast iron can be used for its good corrosion resistance include water, soils, acids, alkalis, saline solutions, organic compounds, sulphur compounds, and liquid metals. In some cases, alloyed cast iron is the only economical choice for the equipment manufacture.

Corrosion of Cast Steels

Cast steels are generally classified into the categories of (i) carbon (C) steels, (ii) low alloy steels, (iii) corrosion resistant steels, and (iv) heat resistant steels, depending on the alloy content and the planned usage. Steel castings are categorized as corrosion resistant if they are capable of sustained operation when exposed to attack by corrosive agents at operating temperatures which are generally below 300 deg C.

The high alloy iron base compositions are generally given the name ‘stainless steels’, though this name is not recognized universally. Actually, these steels are widely referred to as cast stainless steels. Some of the high alloy steels (e.g. 12 % chromium steel) show many of the familiar physical characteristics of C steels and low alloy steels, and some of their mechanical properties, such as hardness and tensile strength (TS), can be altered by suitable heat treatment. The alloy steels of higher chromium (Cr) content (20 % to 30 % Cr), Cr-Ni (nickel) steels and Ni-Cr steels do not show the changes in phase observed in ordinary C steel when heated or cooled in the range from room temperature to the melting point. Consequently, these steels are non hardenable, and their mechanical properties depend on the composition instead of heat treatment.

Corrosion of carbon and low alloy cast steels

Unless protected by a protective coating, cast steels like any other iron and steel materials corrode in the presence of O2 and water. Hence, cast steels corrode when it is exposed to moist air. The rate at which corrosion continues in the atmosphere depends on the corroding medium, the conditions of the particular location in which the steel is in use, and the precautions which have been taken to prevent corrosion. The rate of corrosion also depends on the quality of the cast steel as determined by its chemical composition and heat treatment. The likely rate of corrosion of the cast steel in an atmosphere can normally be estimated only from tests carried out for a long time.

Cast steels and wrought steels of similar analysis and heat treatment show about the same corrosion resistance in the same atmospheres. Plain C steels and some of the low alloy steels do not generally resist severe corrosive conditions, although there are some exceptions, such as strong sulphuric (HaSO4) acid. For increasing the corrosion resistance of cast steel substantially, it is essential to use extensive alloying of the cast steel. Small amounts of Ni and copper (Cu) slightly increase the corrosion resistance of the steel to the atmospheric attack. However, substantially larger amounts of other elements, such as Cr or Ni improve resistance considerably.

In case of atmospheric corrosion, tests carried out to compare the corrosion resistance of several cast steel samples in industrial and marine atmospheres at many places with surfaces of half the specimens machined have shown that the conditions of the sample surface have no significant effect on the corrosion resistance of cast steels. Unmachined surfaces with the casting skin intact have shown corrosion rates similar to those of the machined surfaces regardless of the atmospheric conditions. The maximum corrosion rates have been noticed in the marine atmosphere around 25 m above the ocean surface, with lower but similar corrosion rates occurring in the industrial atmosphere and the marine atmosphere around 250 m above the ocean surface.

The corrosion rate of cast steels decreases as a function of time, since corrosion products (scale coating) build up and act as a protective coating on the cast steel surface. However, the corrosion rate of the many corrosion resistant cast steels (with 2 % Ni) is always less than that of lesser corrosion resistant cast steels. Cast steels containing small percentages of Ni, Cu, or Cr as alloying elements have better corrosion resistance than that of cast C steels and those containing Mn when exposed to atmospheric conditions. Increasing the Ni and the Cr contents of cast steel increases the corrosion resistance in all the atmospheric conditions mentioned above.

All cast steels have better corrosion resistance than malleable cast iron in industrial atmospheres and are superior or equivalent to the wrought steels in these atmospheric conditions. The corrosion rate in the marine atmosphere depends mainly on the alloy content of the cast steel. The corrosion resistance of cast C steel is much superior to that of similar wrought steel, but is slightly inferior to malleable cast iron.

Corrosion studies done for several low alloy cast steels and high alloy cast steels in other atmospheric conditions (high temperature steam at 650 deg C, petroleum products atmosphere) have shown that the corrosion resistance of cast steels improves as the content of Cr increases in the cast steels.