

A REVIEW OF CORROSION BEHAVIOUR ANALYSIS STUDIES OF DIFFERENT STAINLESS STEEL GRADES IN DISTINCT ENVIRONMENTS

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Abstract-Widely used stainless steel grades such as 304, 316, 316L, 321, 430 etc. has many applications in food industry, paper and pulp industry, chemical industry, medical device industry, heat exchangers, households and many other areas due to its affordable cost, availability, ease of fabrication and welding as compared to some other materials. Stainless steel are also the most suitable candidates for various marine applications like work boat propellers, pump components, valves, shaft components and oceanographic instruments due to their excellent corrosion resistance especially for pitting and crevice. The selection of a particular type of stainless steel will depend on the particular application. Environment, expected part life, mechanical properties such as strength, hardness etc. and extent of acceptable corrosion help to determine the type of stainless to be used. Corrosion of stainless steel is a destructive attack and an undesirable phenomenon which destroys the luster and beauty of objects and shortens its life. So for the selection of a particular type of stainless steel, its corrosion behavior should be analyzed for the specific application. Various researchers had studied the corrosion behavior of different grades of steel in distinct environments by using different techniques. This paper summarizes recent research work which has been carried out to analyze the corrosion behavior of different grades of steel in distinct environments.

Keywords: Stainless steel, Corrosion, Electrochemical Impedance Spectroscopy, Potentiodynamic Polarization.

1. INTRODUCTION

The world consumption of stainless steel increases 6% per annum. The containers made of stainless steel are preferably used for alcoholic fermentation because of many advantages of stainless steel tanks over other materials such as ease of cleaning, comparative chemical inertness, e.g. no addition of flavors or contaminants (Alar et al. 2016). Stainless steel are also the most appropriate for oceanic applications like shafts, propellers and valves etc. of work boat (D. B. Kumar et al. 2015). In present days, stainless steel and some other materials also put into use as a bio-implant material. Austenitic stainless steel possess reasonable corrosion resistance, tensile strength, fatigue resistance and suitable density for load bearing purposes thus making this material a preferable for biomedical application. In chloride environment, corrosion resistance originates from a chromium rich oxide layer, which works as a barrier against ion diffusion between the alloy and the ambient phase (Avstenitnih and Lastnosti 2014). The passive film stability and the corrosion resistance of stainless steel increase with increasing chrome content in the alloy (N. Kumar et al. (2014). Stainless steel also has addition of nickel, molybdenum and manganese to improve corrosion resistance. Stainless steel normally used in industries where both the properties of steel like strength and resistance to corrosion are required.

There are various types of stainless steel such as austenitic, ferritic, martensitic and duplex stainless steel. Austenitic stainless steel (such as 304, 316 and 321 etc.) has a Face-Centered Cubic (FCC) crystal structure. It has high ductility, low yield stress and relatively high ultimate tensile strength as compare to typical carbon steel. When austenitic stainless steels are exposed to the critical temperature range of 425–870 °C for a given period of time, chromium carbides are formed at the grain boundaries and Cr depletion occurs adjacent to these carbides, affecting their corrosion resistance (Della Rovere et al. 2013). It is especially used in the food and beverage manufacturing, medical device manufacturing. Ferritic stainless steel (such as 405, 409 and 429 etc.) has enhanced corrosion resistance than mild steel but similar properties like tensile strength and hardness etc. It is strongly magnetic and less ductile than austenitic stainless steel. Ferritic stainless steels are subjected to pitting and crevice types of corrosion in the tar sand digester medium (Umoru et al. 2008). It's typical application found in automotive exhaust systems, kitchen counters and sinks. Martensitic stainless steels (such as 403, 410 and 420 etc.) are similar in composition to the ferrite group like phosphorus, manganese and silicon etc. It has a BCC structure. It developed in order to provide a group of stainless steels which are corrosion resistant and hardenable by heat treatment. It is used for manufacturing turbine blades and multi-purpose tools. Duplex stainless steel has a ferritic and austenitic lattice microstructure, with a phase balance of approximately 50% ferritic and 50% austenitic. It is magnetic due to the ferrite content. Duplex stainless steels are widely used in oil and gas industry.

The selection of stainless steel grade depends on environment of its application. Corrosion resistance is the primary factor, followed by stain and oxidation resistance so the extent of acceptable corrosion helps to determine the type of stainless steel to be used.

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Corrosion is the destructive attack on a metal by chemical or electrochemical reaction with its environment. It is known commonly as rust. Millions of dollars are lost each year due to corrosion of iron and steel. Steel structures are subjected to different forms of corrosion during service in different media. Some of these forms are pitting, crevice corrosion and stress corrosion cracking etc. (Iliyasu I et al. 2012).

In general corrosion, surface layers of metal is converted to corrosion products in such a way that the thickness of the section is uniformly decreased. The 8.03% nickel contained in the steel assists in providing resistance to uniform corrosion in fairly reducing environments of H_2SO_4 at low concentrations (Iliyasu I et al. 2012). Pitting corrosion is a form of localized attack that results in localized penetration of the metal. It is generally focused on a small area of metal surface, and always causes the devices to fail by initiates stress corrosion cracks (Tian et al. 2014). The pitting corrosion is caused by the potential difference between the anodic area inside the pit and the surrounding cathode area. Pitting corrosion resistance depends more strongly on the removal of surface in homogeneities, such as inclusions (Ahmadian et al. 2014). Crevice corrosion is an intensive localized corrosion occurs within crevices between two joining surfaces and other shielded area on metal surfaces exposed to a corrosive environment. Molybdenum increases the stability of the passive film and the ability of the stainless steel to resist localized corrosion, including crevice corrosion in the environment containing chloride ions (Avstenitnih and Lastnosti 2014). Under the combined effect of stress and corrosion, stainless steels will be subject to a more rapid and severe corrosion, and also stress corrosion cracking (Martins et al. 2014). It can lead to unexpected sudden failure without warning, especially at elevated temperature. This effect has been seen in low pressure turbine disks and blade roots and also in boiler tubes. Erosion corrosion involves both mechanical and electrochemical mechanism and combined effect of this produces an increased material loss. It is a tribo-corrosion material loss due to the flowing fluid which damages the surface layer as well as the base metal (Jayabharathy et al. 2015). Erosion corrosion is promoted by high fluid velocity and turbulent flow.

Corrosion cannot be avoided, but it can be controlled and prevented by using suitable methods like cathodic protection, metallic coating, alloying and using inhibitors, etc (D. B. Kumar et al. 2015). Corrosion rate is dependent on both corrosion potential and concentration of ions present (Ningshen et al. 2011).

The stainless steel protect from corrosion attack by the formation of passive film which based on the presence of a thin chromium oxide film on the surface which decreases the electrochemical reaction. The passive film has a thickness of 1-3 nm on stainless steel. Chromium content higher than 13 wt% promoted the formation of a passive layer of chromium oxide/hydroxide on the surface that reduces the corrosion rate of stainless steel in aqueous media (Farias and Lins 2011). The passive film formed on stainless steel exhibits a duplex structure consisting of an inner chromium-rich oxide layer in contact with substrate and an outer iron-rich oxide and hydroxide at the film-electrolyte interface (Zheng et al. 2014). Other elements present in the passive film are nickel, found in the inner layer of the passive film, and molybdenum found in the outer layer.

There are numerous conventional electrochemical techniques used for corrosion studies of stainless steels such as electrochemical impedance spectroscopy (EIS), potentiodynamic measurement, weight loss method, potentiostatic testing and galvanostatic testing. These are used to characterising corrosion rates of the stainless steel and studying pitting/repassivation phenomena. They provide information about the corrosion mechanism over the entire exposed surface of the stainless steel in the electrolyte. This may be in the form of an average potential or corrosion current or impedance, or as a temperature at which the passive film breaks down and pitting occurs. However, in most of the cases of localised corrosion on stainless steel, specific features or defects in the microstructure or passive film have an important role in the process and form anodic or cathodic sites in the corrosion process. The study of the location of anodic and cathodic sites over the surface is crucial to understand the corrosion process in localised corrosion of stainless steels.

2. LITERATURE SURVEY

Many author tried to describe the literature review concerned with corrosion behavior of different stainless steels grades used for diverse applications.

Umoru et al. (2008) investigated the corrosion properties of three types of stainless steels SS 304, SS 321 and SS 430 in a tar sand digester environment. The non-electrochemical immersion technique was used to investigate the corrosion rate in miles per year (mpy). The spectroscopy analysis of the tar sand was done by the energy dispersive x-ray analysis (EDS) and surface study to reveal the form of corrosion by scanning electron microscopy (SEM). The result revealed that the austenitic stainless steels grades (AISI 304 and 321) have better corrosion resistance behaviour than the ferritic stainless steel grade SS 430. When comparing the two austenitic grades (AISI 304 and 321) then SS 321 showed better corrosion resistance than SS 304 in tar sand digester medium. The SEM analysis of ferritic grade SS 430 samples after twenty days immersion showed a greater tendency to pitting or crevice corrosion than austenitic grades SS 304 and SS 321.

Ningshen et al. (2011) investigated the corrosion behaviour of AISI type 304L SS in different concentration of nitric acid media (0.01 M, 1 M and 5 M) in presence of oxidizing ions at different temperatures (room temperature, 50°C and 70°C). The potentiodynamic polarization and electrochemical impedance spectroscopy measurement were conducted to investigate the corrosion behaviour of 304L SS specimens. Laser raman spectroscopy (LSR) measurement were performed to study the passive film concentration on samples developed with passive film formed by potential sweep in the anodic direction to passive region and by holding potentiostatically at passive region for 1 h. The LRS result revealed the presence of NO_3^- , CrO_4^- and $Cr_2O_7^{2-}$ in passive film in addition to Cr_2O_3 and Fe_2O_3 . The presence of these oxidized species accelerated the corrosion processes. The potentiodynamic anodic polarization results revealed no significant change in corrosion potential

even with increase in temperature and nitric acid concentration in presence of oxidizing ions because any effect on corrosion potential due to generation of large amount of oxidizing nitrate ions is swamped by ions. The metal surface dissolution was observed with increase in temperature and at higher concentrations. The passive film stability is measured by EIS revealed faster passive film dissolution as indicated by low film polarization resistance, with increase in nitric acid concentration and temperature.

Farias and Lins (2011) investigated the corrosion resistance of stainless steel as well as unalloyed and alloyed carbon-manganese steels like (T11, T22, AISI 444, 1020, L80 13Cr, L80 T1, A 423) in neutral and acid sugar cane juice electrolytes. The corrosion resistance evaluated by using autoclaving tests, Tafel analysis, linear polarization technique, and electrochemical impedance spectroscopy (EIS). The results of linear polarization, Tafel analysis and EIS tests proved that in acid sugar cane juice T11 steel exhibited the highest corrosion resistance among the alloyed carbon steels and the result of autoclave testing at pH 7 indicated the good corrosion behavior among the alloyed carbon steels for T22 followed by T11 and A423 steel.

Iliyusu et al. (2012) investigated the susceptibility and resistance of type 304 austenitic stainless steel exposed to sulphuric acids (H_2SO_4) with different concentrations (0.3M to 1M) at ambient temperatures ($30^\circ C$) and at higher temperatures ($40^\circ C$, $50^\circ C$, $60^\circ C$, $70^\circ C$ and $80^\circ C$). Weight loss method was used to examine the corrosion rate of the steel after immersion in the corrosive media. The Constant Extension Rate Tensile Test (CERT) was also performed with a tensometer to determine the susceptibility of the steel to stress corrosion cracking in the corrosive media after seven days exposed and the percentage reduction in area of each test piece was recorded. The stress corrosion cracking (SSC) behaviour of type 304 austenitic stainless steel expressed both the elongation percentage and reduction cross section decreased with increased exposure time and increased concentration. It is observed that the susceptibility of 304 SS to stress corrosion cracking in the corrosive media and its high resistance to uniform corrosion of below 0.1mm/yr.

Singh et al. (2013) had conducted potentiodynamic polarization tests to investigate the electrochemical corrosion behavior of the uncoated, HA, HA + 10 wt% SiO_2 and HA + 20 wt% SiO_2 plasma coated AISI 304 specimens in Ringer solution. The electrochemical study showed the corrosion resistance of the AISI 304 increased after deposition of plasma sprayed HA + 20 wt% SiO_2 compared to uncoated, plasma sprayed HA + 10 wt% SiO_2 and HA coatings on AISI 304. The coatings were characterized by XRD and SEM / energy dispersive X-ray spectroscopy (EDS). The results suggest that with increase the percentage of SiO_2 in coating, corrosion resistance of coated samples increase. The XRD analysis of the samples revealed that after corrosion testing crystalline size of HA and HA- SiO_2 coatings increases and SEM micrographs showed that HA coating retains its morphology where as morphology of HA- SiO_2 coating changes to flattened particles of irregular shape and take a form of small grain boundaries, which make the coating less porous and more corrosion resistant.

Walke and Przdonziono (2013) investigated the corrosion resistance of stainless steel 316L used in cardiologic treatment mainly for vascular stents and analysed the influence of electrochemical and chemical treatment of the stainless steel surface, including sterilisation with pressurised water steam, on its corrosion characteristics. The EIS tests were performed in artificial blood plasma simulating human blood environment. The samples were subject to exposure in artificial blood plasma at the temperature $T = 37 \pm 1^\circ C$ for 30 days. EIS tests proved that chemical passivation process has favorable impact on corrosion resistance of AISI 316L steel.

Della Rovere et al. (2013) investigated the corrosion behavior of 304 stainless steels after exposure to different temperatures for different interval of time. The chemical composition of stainless steel is determined by spark optical emission spectrometry to identify the type of austenitic stainless steel. The immersion tests were carried out in a boiling solution of 50% (H_2SO_4) + 2.5% ($Fe_2(SO_4)_3$) for 120 h and after the test, the specimens weight loss was determined and the corrosion rate in mils per month penetration was calculated. The extent of the sensitization phenomenon in SS 304 has been measured effectively through the double loop electrochemical potentiokinetic reactivation (DL-EPR) test. Surface morphology was analysed using SEM. One specimen was furnace sensitized to $600^\circ C$ for 1 h for comparison of result. The result obtained that exposure to fire changed the microstructures and corrosion properties of SS 304 plates in several areas of the fermentation tanks. The behavior of most of the fire-exposed specimens was similar to that of the furnace-sensitized specimen, and the reactivation peak current density indicated the presence of intergranular sensitization. Most of the fire exposed specimens showed significantly higher values of degree of sensitization (DOS) than the non-fire exposed specimen. The non-fire-exposed specimen showed no signs of intergranular attack. Severe intergranular corrosion occurred on the surface of some of the fire-exposed specimens and a less pronounced intergranular corrosion attack was observed that presented "step" and "dual" structures. In addition, spots of localized corrosion were also found in the entire surface morphologies after the DL-EPR test, but their incidence was much higher in the fire-exposed specimens.

Zheng et al. (2014) investigated the fine microstructure of the passive films on nano crystalline (NC) and coarse crystalline (CC) 304 stainless steels in 0.5 M H_2SO_4 . The passive film formed on SS exhibits a duplex structure consisting of an inner chromium-rich oxide layer in contact with the metallic substrate, and an outer layer of iron-rich oxide and hydroxide at the film-electrolyte interface, with a total film thickness of a few nanometers. The potentiodynamic polarization curves, EIS, X-ray photoelectron spectroscopy (XPS) and AFM used for investigation. The potentiodynamic polarization showed that the NC sample has more positive E_{Corr} and I_{Corr} than CC SS, indicating that the stability of the passive film, and subsequently the corrosion resistance of 304 SS in 0.5 M H_2SO_4 solution, is increased after nanocrystallization by equal channel angular

pressing (ECAP). XPS results reveal that the passive films formed on both CC and NC 304 SSs in 0.5 M H₂SO₄ solution has similar composition and microstructure.

Ahmadian et al. (2014) investigated the effect of different surface preparation methods such as electro polishing (EP), mechanical polishing (MP), chemical passivation (CP), acid cleaning (AC) and ultrasonic cleaning (UC) on the formation, stability and deterioration of surface films formed on austenitic 304 stainless steel. The behaviour of surface analysed by cyclic polarization curve and AC impedance measurement surface techniques of austenitic stainless steel 304 in Tyrode's solution was investigated. SEM, EDX and AFM were used to characterize specimen's surface before and after tests. The result revealed that EP treatment shows the most corrosion resistance and is the most effective surface treatment and CP treatment shows the low pit resistance and passive film to be less protective, While UC treatment shows a high pitting resistance. The Acid cleaning treatment is active than respect to the MP and Surface roughness is reduced in MP, also small variations are observed due to different surface preparations. As can be seen surface treatment specially electro polishing can increase the uniform and pitting corrosion resistance of implant stainless steel in physiological solution due to improving passivation and protective surface layer.

Singh et al. (2014) studied the effect of contents of calcium phosphate (CaP) on corrosion behaviour of hydroxyapatite (HA) coatings in simulated body fluid (Ringer's solution). Three types of coatings, i.e. HA + 20 wt% CaP (type 1), HA + 10 wt% CaP (type 2), HA (type 3), were laid on 316L SS using plasma-spraying technique. Electrochemical potentiodynamic tests were conducted to determine the corrosion resistance of uncoated and coated samples. The characterization techniques XRD, SEM and EDX were used to investigate the crystalline size, microstructure and morphology samples. The electrochemical study showed that the deposition of plasma sprayed type 3 coating on 316L SS increase the corrosion resistance compared to uncoated, type 1 and type 2 plasma-sprayed coating on 316L SS in Ringer's solution. The SEM micrographs showed that HA coating retains its morphology, whereas the morphology of HA + 20 wt% CaP and HA + 10 wt% CaP coatings changes to flattened particles before and after corrosion testing in Ringer's solution and XRD analysis showed plasma-sprayed type 2 and 3 coatings are more crystalline than type 1 coating on 316L SS.

Tian et al. (2014) had observed the metastable pitting behavior of 304 SS in 3.5% (mass fraction) NaCl solution, under different applied potentials by potentiostatic polarization. The Pit morphology observations were obtained using a three-dimensional video microscope. The effects of applied potential on pitting nucleation numbers, pit average lifetime, average peak value of current transients and pit growth rate were also obtained. The results showed that the dissolution rate of metastable pits increased with time, and peaked before repassivation. The average lifetime of metastable pits decayed with potential. Whereas maximum pit lifetime, average peak value of current transients and pitting nucleation numbers increased with potential. Metastable pits were transformed from cone-shaped to dish-shaped during metastable growth. The ohmic potential drop presented between the pit interior and bulk solution, but the growth controlling factor was metal cations diffusion.

Avstenitnih and Lastnosti et al. (2014) investigate and compare the corrosion resistance of austenitic AISI 316L SS in sea water and in pure 3.5 % NaCl using Potentiodynamic measurements and EIS. The measurements of the potentiodynamic tests are compares four potentiodynamic curves, which represent four different immersion times: two in 3.5 % NaCl and two in real seawater (after 1 hour of stabilization at the open-circuit potential in the solution and after 100 hour in the solution). The results obtained that a slight decrease in the chromium oxide content close to the oxide/ solution interface at 100 h exposure in sea water. The EIS show that long-time exposure of the stainless steel AISI 316L differ significantly and should be considered when testing with "artificial" seawater. These differences in the electrochemistry measurement results are probably due to bio-fouling on the surface.

Martins et al. (2014) had observed corrosion behavior of 304 SS tubing of a water system and 316 SS piping system of gas distribution. The electrochemical experiments were performed to investigate the corrosion behavior of SS 304 and SS 316 sample in hypochlorite solution. The characterization and morphology of the sample were examined by SEM/EDS. The result revealed that the stainless steel 304 and 316 are not suitable materials for being in contact with vapor containing the hypochlorite ion, due to the potential development of dry/wet conditions that induce pitting corrosion. The analysis by SEM/EDS of some areas in the surface show clear the presence of chlorine, which come to confirm that the surface of the 316 SS tube is submitted to pitting corrosion.

N. Kumar et al. (2014) studied the corrosion resistance of austenitic stainless grade 316 in one mole hydrochloric acid solution. The electrochemical potentiostatic polarization method was used to perform the corrosion behavior of 316 SS samples. The electrochemical behavior of type 316 austenitic stainless steel in acidic solutions depends considerably on the concentration of hydrochloric acid environment. The presence of acid concentration produces and enhancement of metal corrosion through the passive layer, and decreases the passivity breakdown potential. The more active corrosion reactions in presence of chloride ion results in pitting corrosion observed on the metal surface.

Lv et al. (2015) investigated the atmospheric corrosion behavior and mechanism of 304 stainless steel subjected to a simulated marine atmosphere (0.5% NaCl), including the initiation and development of pits, the composition evolution of corrosion products, and the protective ability of corrosion products and the protective ability of corrosion product. The methods used to performed corrosion behavior were potentiodynamic polarization and EIS. The pits morphologies were observed using SEM and elemental composition of corroded specimen was analyze by EDX. The result reveals that the pit depth of corrosion products formed on specimen's surface increased with time. Morphology result shows the small pits

formed on the surface and EDX indicate the composition of corrosion products around the pit was alloy elements such as Fe, Cr, Ni and Mn and in the pit includes S with alloy element.

Ribeiro et al. (2015) studied the electrochemical technique EIS used for the evaluation and investigate the corrosion behavior of metal in reinforced concrete. Electrochemical impedance spectroscopy (EIS) is a powerful technique for characterizing a wide variety of electrochemical systems. The protection of the steel in concrete is done by two ways: through a physical barrier, by the covering layer and due to chemical action that results from typical pH of concrete to allow the development of a passivation film on the rebar. The interpretation of the EIS measurement is done by the correlation between the impedance data and the equivalent circuit representing the physical processes taking place in the system under investigation or through graphics. The Nyquist diagram consists of a series of points, which represent the magnitude and direction of the impedance vector of a particular frequency, where X-axis is the real part (resistive terms) and Y-axis is the imaginary part (capacitive or inductive terms). The Bode diagram consists of an orthogonal axes plane, in which they have, on Y-axis, two quantities: the logarithm of the impedance ($\log |Z|$) in ohms (Ω) and the phase angle (Φ) in degrees; and on X-axis there is the logarithm of the frequency ($\log f$), in Hertz (Hz).

D. B. Kumar et al. (2015) examined the corrosion behavior of SS 316L in presence of Sodium hydroxide, Hank's solution, Ringer solution and Seawater. The electrochemical potentiodynamic polarization method was used to investigate the corrosion behavior of samples. The result revealed that the linear polar resistance (LPR) values are increasing and I_{Corr} values are decreasing from 5% hydroxide solution to ringer solution. The order of corrosion resistance of SS 316L in different medium was Ringer solution > seawater > Hank's solution > sodium hydroxide.

Jayabharathy et al. (2015) investigated the erosion corrosion behavior of 316L SS in a particular velocity with various concentrations of NaCl and KCl such as 5 g/l, 10 g/l and 15 g/l solutions at atmospheric conditions. The weight loss method was used to determine the corrosion rate. The result showed that erosion corrosion rate is higher in a sodium chloride (NaCl) environment than potassium chloride (KCl) environment. The protective layer and salt film are removed by the moving fluid, allowing the dissolved oxygen to come in contact with corroded surface, influencing greater material loss than by the individual effect.

Alar et al. (2016) investigated the corrosion behavior of SS 304, SS 316 and SS 316 Ti in Red Wine, White Wine and Beer. The cyclic potentiodynamic polarization method gravimetric method and was used to determine the corrosion rate of the samples. The surface morphology of the SS was observed with SEM. The result revealed that the largest loss of mass was exhibited by sample AISI 304, after it was exposed to beer. The strongest deviation in terms of roughness was measured in sample AISI 316, after it was exposed to red wine. The highest susceptibility towards pitting corrosion is exhibited by the steel in the AISI 316Ti sample, after it was exposed to beer. SEM results show the dissolution of metallic ions from the surface.

Lins et al. (2016) investigated the corrosion resistance of SS 304 and SS 444 used in the food industry using sanitizing electrolytes: calcium hypochlorite and Divosan (aqueous solution of 0.25% v/v peracetic acid, 0.25% v/v acetic acid, 0.25% v/v hydrogen peroxide) employed in the clean-in-place (CIP) procedure, and using electrochemical techniques such as potentiodynamic anodic polarization and electrochemical impedance spectroscopy. The results revealed that the austenitic AISI 304 steel showed the highest corrosion resistance than SS 444 in sanitizing electrolytes used in the Clean-in-Place (CIP) process of the food industry due to higher contents of nitrogen and nickel in SS 304.

3. SUMMARY

Many authors have carried out investigation on various grades of steel in different environment to depict the best for particular environment to reduce the corrosion effect. It was found that austenitic stainless (304, 321) have better corrosion resistance behavior than ferritic stainless steel grade 430 in tar sand digester while 304 SS also has highest corrosion resistance than SS 444 in sanitizing electrolyte used in process of cleaning of food industry. But when we compare the austenite grades then observed that SS 321 has better corrosion resistance than 304 SS in tar sand digester environment. SS 304 also exhibited largest loss of mass than other austenitic grade such as SS 316 and 316 Ti, after it was exposed to beer. The austenitic grade 316L has higher corrosion resistance behavior in potassium chloride (KCl) than sodium chloride (NaCl) environment, while 316L also have higher corrosion resistance behavior in ringer solution than sea water, hank solution and sodium hydroxide. It was also seen that corrosion resistance of SS grades improve by applying the different surface preparation methods such as electro polishing (EP), mechanical polishing (MP) and acid cleaning (AC) etc.

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