Fabrication of Lowcost Saltspray Chamber For Testing Corrosion Resistance of Materials

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Abstract—The main aim of this project is to design and fabricate low cost salt spray testing machine which is able to identify the corrosion formation in any type of metals; from this testing process we can improvise the life span of the particular metal. A motorbike has a paint coated footrest made of stainless steel, so this part when comes in contact with atmosphere nearly after a year it is corroded so if salt spray testing machine is used at this point can found out that for additional coating of paint, whether it will withstand up to longer duration likewise, this process can be analysed. This salt spray testing machine is fabricated for low cost and the stainless steel grade 316L is tested and analysed.

Keywords—salt spray, 316L SS, weight loss, corrosion.

I. INTRODUCTION

The salt spray test is a popular test corrossion method; it is used to measure the corrosion resistance of materials at high temperature. The salt spray test in other words ASTM B117 and fog testing .This salt spray test implements the corrosive attack to the samples which is coated completely on the selected material.

II. HISTORY OF SALT SPRAY TESTING MACHINE

In the year 1939 ASTM B117 was recognized as the first international salt spray standard. The formation of rust is evaluated after a pre-determined period of time. Time duration completely depends on the corrosion resistance of the coating, in general if the corrosion resistance is coated more may be five or six layers then it takes longer period of time to appear rust or corrosion.

The temperature which is standard maintains at 95°F (+34°F to 35°F) (35°C (+ 1.1°C to 1.7°C)) and the pH range of 6.5 to 7.2 with a 5 parts sodium chloride to 95 parts ASTM D1193 Type IV water of salt atmosphere is introduced into the chamber at specific air pressure.

Synthetic seawater solutions are also commonly used and preferred by some companies and standards. In some other test solutions has different chemicals added including aceticacid ( ASS) and acetic acid with copper chloride ( CASS) each of them are chosen for the coatings, such as electroplated copper-nickel-chromium, electroplated copper-nickel or anodized aluminum.so the above acidified test solutions basically have a pH of 3.1 to 3.3.

Some sources never use the CASS, it is claimed that a proper cleaning of the cabinet after the process of CASS test is very difficult.

It is generally used in various following sectors like Industry, Marine, Automotive, Aircraft and military equipment

ASTM G85 annex A1 – Acetic Acid Salt Spray Test (non-cyclic)
ASTM G85 annex A2 – Acidified Salt Fog Test (cyclic)
ASTM G85 annex A3 – Seawater Acidified Test (cyclic)
ASTM G85 annex A4 – SO2 Salt Spray Test (cyclic)
ASTM G85 annex A5 - Dilute Electrolyte Salt Fog/Dry Test (cyclic) these are the some of the modified salt spray tests, so each and every one is suitable for the specific material.

So the chamber construction, testing procedure and testing parameters are internationally standardized such as ISO 9227. The testing standards may provide information of testing periods for the coatings to be analysed, nor the appearance of corrosion materials in form of salts. Artificial seawater which is sometimes used for Salt Spray Testing can be found at ASTM International. The standard for Artificial Seawater is ASTM D1141-98 which is the standard practice for the preparation of substitute ocean water.

III. STAINLESS STEEL

The word of “stainless steel” clearly signifies that ignore stain or rust. Stainless steel is an alloy of Iron with a minimum of 10.5% Chromium. Chromium produces a thin layer of oxide on the surface of the steel known as the ‘passive layer’. This prevents any further corrosion of the surface. Increasing the amount of Chromium gives an increased resistance to corrosion.

Stainless steel also contains varying amounts of Carbon, Silicon and Manganese. Other elements such as Nickel and Molybdenum may be added to impart other useful properties such as enhanced formability and increased corrosion resistance.

Application of Stainless Steel

The stainless steel are used in many places such as architecture, pulp, paper, biomass conversion, petro chemical & chemical processing, food & beverages, medicine, jewelry, 3D printing, etc…
Pharmaceutical Field

So there are different types of grades like 302, 304, 304L, 316, 316L, 410, 430, 440 etc., but there are selective grades used in pharmaceutical. Pharmaceutical equipment is made of the material that should not react with the active material or excipients used in pharmaceutical manufacturing. There are 4 types of stainless steel used in pharmaceutical equipment manufacturing 304, 304L, 316 and 316L. The 316 and 316L are the grades have a direct contact with the pharmaceutical products including water system and pipelines whereas 304 is used in non-contact parts.

The grade with “L” signifies the low amount of carbon 0.03%.

- Improved machinability compared to normal grade.
- 10-50% improvement in productivity depending on grade and component
- Can be applied to austenitic, martensitic and PH grades, for example 304, 316, 420, 431, 17-4 PH
- No significant effect on corrosion resistance (unlike conventional free-cutting, high sulphur grades)

All grades resist damage from aldehydes and amines, though in the latter case grade 316 is preferable to 304; cellulose acetate will damage 304 unless the temperature is kept low. Fats and fatty acids only affect grade 304 at temperatures above 150 °C (302 °F), and grade 316 above 260 °C (500 °F), while 317 is unaffected at all temperatures. Type 316L is required for processing of urea.

IV. COMPONENTS USED

Square tubes, Stainless steel sheet, FRP basket, Manifolds, One way or one touch fitting, RO pipe tubes, Nipple fitting, RO booster pump, Hinges, Fasteners are the components used to fabricate the testing machine.

V. DESIGN SPECIFICATION

Frame
- Length-1200mm
- Breadth-600mm
- Height-700mm

Fiber reinforced plastic
- Maximum size {working chamber}
  - Length-800mm(from exterior)
  - Breadth-550mm(from exterior)
  - Height-450mm(from exterior)
- Minimum size {solution collector}
  - Length-400mm(from exterior)
  - Breadth-550mm(from exterior)

- Height-150mm(from exterior)

RO booster pump
- Flow rate-1.80L/min
- Voltage -240V DC
- Suction Height-2M
- Working Pressure-70-130 psi
- Dimensions-200*200*100mm
- AMP-0.9A
- Capacity-100GPD

Circuit components
- Breakers MCB
- Conductors -2 (motor & heater)
- Temperature controller
- Digital timer
- ON/OFF Push buttons

VI. FABRICATION

The main core of the fabrication is the design and frame, the frame is constructed through square tubes and arc welded. After that the frame are covered by the stainless steel sheets on all four sides. Now the frame is divided into 2 portions, one portion is the working chamber which occupies major portion and the rest is the salt solution storage tank which is known to be sump, there are two booster pumps which is placed above the sump. The pump sucks the salt solution and delivers to manifolds. The specimen is placed in between the two manifolds in the hanging position. Now the salt solution is sprays on the specimen through two manifolds, thus the specimen gets wet fully. The excess salt solution in the working chamber is transfer to sump.
VII. WORKING PRINCIPLE

When the power supply is generated, the booster pump sucks the salt solution from the sump, at that time the timer starts automatically. From the sump it directly distributed to the manifolds and then to the sprayer, the sprayer sprays it to the specimen chosen for 72 hours continuously. This process is completely based on the weight loss method.

VIII. WEIGHT LOSS TESTING METHOD

The SS 316L is selected for testing. Grade 316L is the standard molybdenum-bearing grade then the second preference given to the 304 amongst the austenitic stainless steels. The Molybdenum gives 316L better corrosion resistant properties than the grade 304. Grade 316L is the low carbon version of 316 and is the grain boundary carbide precipitation. This is mainly used in heavy gauge welded components over about 6mm. The austenitic structure has excellent toughness on these grades, even at the cryogenic temperatures. Compared to chromium-nickel austenitic stainless steel, 316L stainless steel offers higher creep, stress to rupture and tensile strength at elevated temperatures.

<table>
<thead>
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<th>Alloy</th>
<th>C</th>
<th>Si</th>
<th>S</th>
<th>P</th>
<th>Mn</th>
<th>Ni</th>
<th>Cr</th>
<th>Mo</th>
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</thead>
<tbody>
<tr>
<td>AISI 316L</td>
<td>0.03</td>
<td>0.46</td>
<td>0.02</td>
<td>0.02</td>
<td>1.8</td>
<td>11.2</td>
<td>16.0</td>
<td>2.0</td>
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The chosen grade 316L is 150*150*10 mm. Clean the specimen which is chosen for testing and then specimen weight is noted before testing. The weight is around 880g. Place the specimen in the working chamber. The process takes place for 72 hours. After 72 hours the specimen is taken from the chamber and observes the red rust formation in the specimen. Dry the specimen and weighted. The weight is 875g. Weight difference between before and after testing is 5g. Thus the weight loss testing is carried out successfully through the salt spray testing machine.

IX. RESULT

A specimen stainless steel grade 316L is tested with this fabricated salt spray testing machine and the output of the specimen is obtained by weight loss method. From this corrosion mechanism the opted out the materials which can also be used in automotive, marine, even in day to day life. It always never deals with the automotive parts or marine parts but also the materials that are in regular use such as knife, building construction tools, pipes etc. So from this mechanism we can just extend the life of the materials or specimen or automotive parts.

X. CONCLUSION

The salt spray testing machine is adapted to be operated in sequence to faithfully reproduce outdoor conditions. Namely, at first the brine spray is produced, and then the specimens are rinsed, then dried by hot or ambient air, and cooled. The test pieces are moistened to simulate formation of dew on the surfaces of the test pieces and then drying is affected. It will be understood that this cycle of operation, reproducing outdoor conditions, provides a test which has a high degree of conformity with natural outdoor corrosion conditions.

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