The challenges of Dissolved oxygen on Condensate and feed water cycle in thermal power plant

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ABSTRACT:- The condensate and feed water chemistry is critical to the overall corrosion and reliability of the thermal power generating units. The effect of dissolved oxygen on corrosion of WB 36 material and carbon steels in feed and condensate water system. The presence of high levels of dissolved oxygen within condensate can quickly contribute to; accelerated corrosion, the need for additional treatment requirements, increased maintenance, operational challenges and even early equipment failure. The condenser water cycle, dissolved oxygen started increasing at Unit 2 of the VIPL, Butibori. An evaluation of the high condensate dissolved oxygen levels that were being experienced at Unit 2 indicated of the Condensate extraction pump system include mechanical seal vent line, connector, valve gland, dummy plug etc. A new approach to dissolved oxygen control was necessary in the condensate and feed water cycle could be controlled satisfactorily. This paper describes the various corrective actions undertaken as well as proposed for future implementations are discussed and recommendations are provided for proper operation and maintenance.

Keywords :- DO corrosion, leakages, ppb, Feed water system.

I. Introduction

Dissolved oxygen is a prime contributor to corrosion in power plant steam cycles and is affected by a number of vary chemistry related parameters. Major equipment, in particular suffers from various forms of corrosion induced by the presence of dissolved Oxygen. The failure due to corrosion of WB 36 and Carbon steel pipes has been a prominent feature in thermal power plants. Many corrosion problems occur in deaerator, feed water heaters, and economizers. The most common causes of corrosion are dissolved gases under-deposit attack, low pH, and attack of areas weakened by mechanical stress, leading to stress and fatigue cracking. Removal of dissolved Oxygen (DO) from water is a necessary process in many thermal power plants. Acceptable levels of DO vary depending on the intended use of condensate and feed water cycle. Removal of DO is necessary to prevent corrosion in Deaerator, Feed water storage tank, boilers drum, water piping and levels of around 5 ppm are necessary.

- **Effects of Presence of Dissolved oxygen in condensate and Feed Water cycle**

The most harmful of the dissolved gases is oxygen, which can cause pitting of metal. Very small amount of oxygen can cause severe damage, a mixture of oxygen and water is a highly corrosive combination. This corrosive nature doubles with increase in temperature. Further the corrosion of iron forms soluble bicarbonate, which leaves no protective coating on the metal. If oxygen is also present, rust forms and CO2 is released, which is free to form more corrosion. Oxygen corrosion can be recognized by pits, typically found in the top of the steam drum, deaerator, FST or at the feed water line. Oxygen pitting and scale formation can destroy condensate, feed water piping as well as control valve cages choke due to magnetic layer and effect of operation. The amount of dissolved oxygen present in water is very much dependent on the feed water temperature. The solubility of oxygen in water is reduced as the temperature of the water increases. The dissolved oxygen content of water at 20 °C is 9 ppm, at 60 °C is 5 ppm and at 90 °C is just less than 2 ppm. At 100 °C the oxygen content is theoretically 0 ppm. Feed storage tanks are normally operated at approximately 166-170°C, which leaves oxygen content of around 5 ppm. It is not possible to operate at higher temperatures due to the possibility of cavitation in feed pump.

- **Dissolved oxygen control objectives and challenges**

Dissolved oxygen concentrations must be controlled to reduce the likelihood of forming oxygen corrosion cells that can result in pitting of carbon steel. First, it is important to monitor the quantity of residual dissolved oxygen present in the system. Then it is important to assess the effects of this oxygen. The latter is best assessed by measuring the quantity of iron circulating within the system. The pH must be maintained high enough to minimize general corrosion of carbon steel, but not so high that caustic attack can occur. All power plants require boiler feed water DO levels to be below 5 ppb is recommended for thermal power plants. Achieving this low level of Dissolved Oxygen can be removed from water using several of methods broadly grouped into chemical and mechanical systems, which make use of a combination of these methods. Deaerator is mechanical devices that remove dissolved gases from boiler feed water cycle. Deaeration protects the steam system from the effects of corrosive gases. It accomplishes this by reducing the concentration of dissolved oxygen and carbon dioxide to a level where corrosion is minimized. A dissolved oxygen level of 5 parts per billion (ppb) or lower is needed to prevent corrosion in most high-pressure boilers; equipment life is extended at little or no cost by limiting the oxygen concentration to 5 ppb. Dissolved carbon dioxide is essentially completely removed by the deaerator. Hydrazine (N2H4) is a powerful reducing agent that reacts with dissolved Oxygen to form nitrogen and water as follows:

$$N2H4 + O2 \text{-----} N2 + 2H2O$$

At high temperature and pressure, ammonia is also formed, which increases the feed water pH level and reducing the risk of acidic corrosion. Hydrazine also reacts with soft hematite layers on the Deaerator, Feed water storage tank, boiler tubes and forms a hard magnetite layer, which subsequently protects the boiler tubes and pipe from further corrosion. This occurs as a result of the chemical reaction:

$$N2H4 + 6Fe2O3 \text{-------} 4Fe3O4 + N2 + 2H2O$$

Thus in order to reduce or remove the Ammonia, the injection of hydrazine should be reduced or stopped.

- **Problems identification of Dissolved oxygen**

VIPL, Butibori Unit 2 is a 300 MW coal-fired thermal power plant originally designed for full load operation. With the advent of shift and cycling operation of partial load thermal power plants, the problem of effective removal of dissolved oxygen gases has increasingly been addressed by condenser extraction pumps 2A. Since changing over to peaking power operation, the plant has had problems with excessive dissolved oxygen (DO), especially during periods of high load. Operation engineers experimented with different combinations of CEP pumps trial; DO levels at normal were acceptable, when operating at CEP 2B, DO was considerably with in limit. At this CEP 2A in services, DO reach high levels that were unacceptable to plant operation and proved problematic for the plant to identify of CEP 2A issues that led to the higher DO level However, DO remain at unacceptable levels. The result was a 140 ppb in DO reach within half an hour operating at CEP 2A.

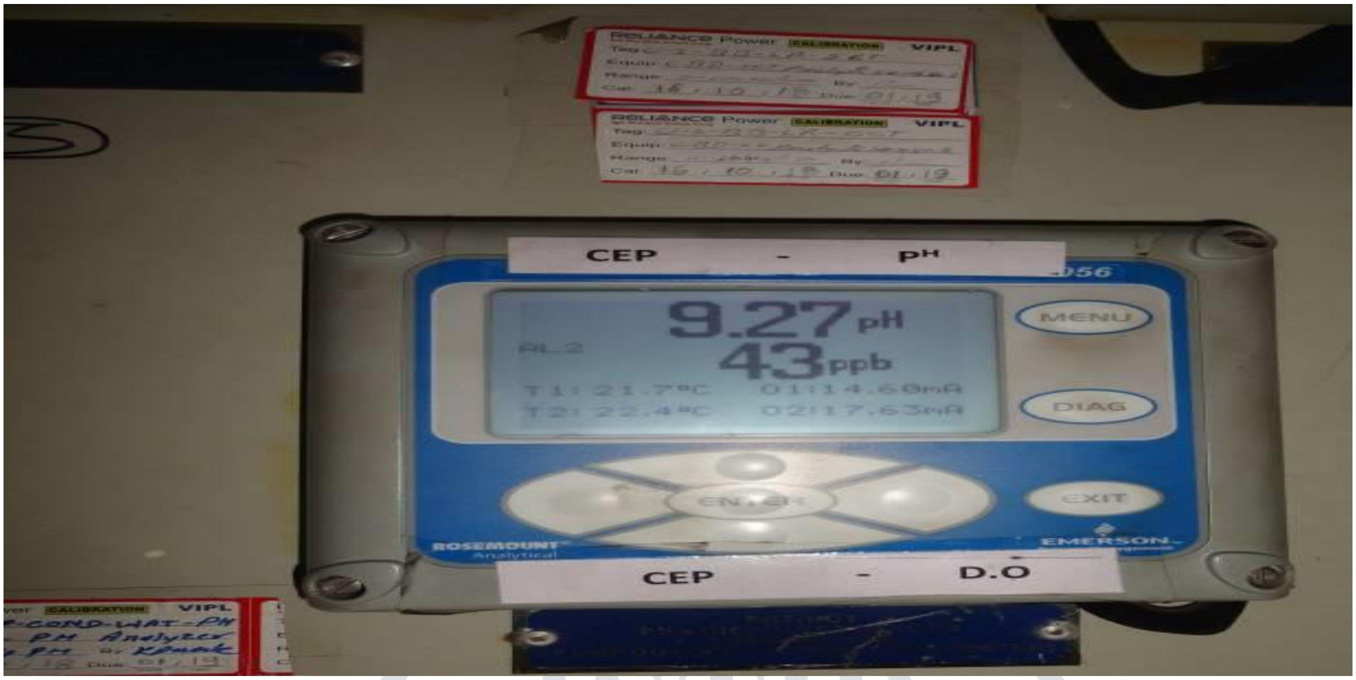

Figure 1. CEP DO in higher level

The plant operation team made numerous attempts at lowering the DO through repairs and operating procedure changes. Plant operation team made several fruitless searches for leaks. The operation team also made many minor repairs, but they had little or no effect on DO. Maintenance engineer even though air in-leakage was identify pressure gauge isolation valve, suction, discharge and strainer flanges, number of connector, dummy plug etc, went so far as to build a dam to flood the standby condensate pump seals, leading to the suck air from seals, yet DO refused to budge.

Before modification of CEP measured Dissolved oxygen present given below table.

Dissolved oxygen			
Date	**Load in MW**	**CEP DO in ppb (< 20 PPB)**	**Deaerator DO in ppb (< 7 PPB)**
11.12.2018	175	37	26
12.12.2018	175	36	29
14.12.2018	175	36	28
15.12.2018	175	119	33
16.12.2018	174	40	30

Table 1 before modification of CEP measured Dissolved oxygen present in system

- **Solution of DO issues in condensate and feed water system**

High DO is often thought to be a necessary evil of CEP 2A operation in services. The higher air in-leakage increases the opportunity for the gases to dissolve oxygen. The higher DO issue was identification and resolution given below.

1. Replace of NRV of DM make up water for mechanical sealing purpose, observed that NRV having flap type in always open in condition, replaced with plug type NRV.

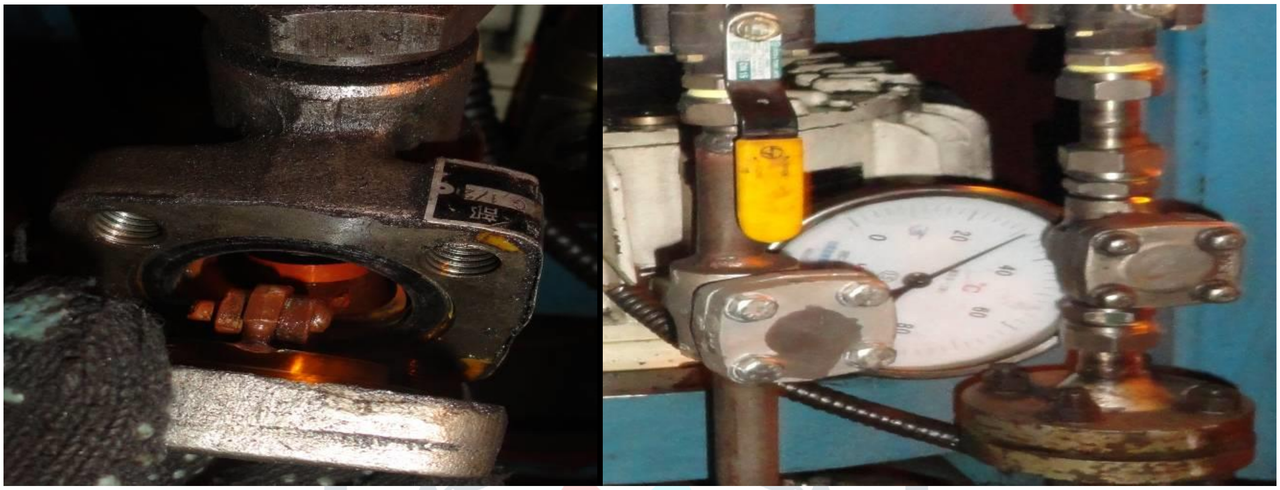

Figure 2. Replace of NRV of DM make up water

For Makeup contains high levels of dissolved oxygen, often exceeding 8000 ppb. If this oxygenated water is enter into the mechanical sealing through DM make up line in small amounts, the effect of DM Makeup water introduced into a CEP canister will raise DO levels well above desired levels and cause damage to downstream equipment. However, HEI limits this makeup flow to 3% if 7 ppb of dissolved oxygen is required.

2. Mechanical seal line vent line connected to canister vent having number of ferroral connector replaced with SS 304 pipe without connector.

Figure 3 Mechanical seal line vent line having number of connector joint.

Leaks in the condensate extraction pump can be eliminated by flanges joints, water sealing and other means. Air entering the condensate extraction pump from mechanical seals and other sources by the venting line connector. To prevent oxygen in the feed water cycle from dissolving into the condensate, the oxygen partial pressure within the condenser must be so low, in accordance with Henry's Law, that no more than 7 ppb of oxygen can go into solution.

Figure 4 replacing connector joint to welded valve and fitting.

3. CEP discharge make up line having orifice not build up pressure in mechanical seal required 2- 6 bar, but orifice size 2 mm not developed pressure, it increase 8-10 mm orifice size depend upon pump capacity with discharge pressure.

Figure 5 modification of CEP discharge make up line orifice.

4. All dummy in suction and canister vent are fully tighting or replaced with new one.

Figure 6 replacement of old dummy by SS material

5. Number connector in mechanical sealing line replaced with all new o rings, gasket and all flange cover with sealing tape.

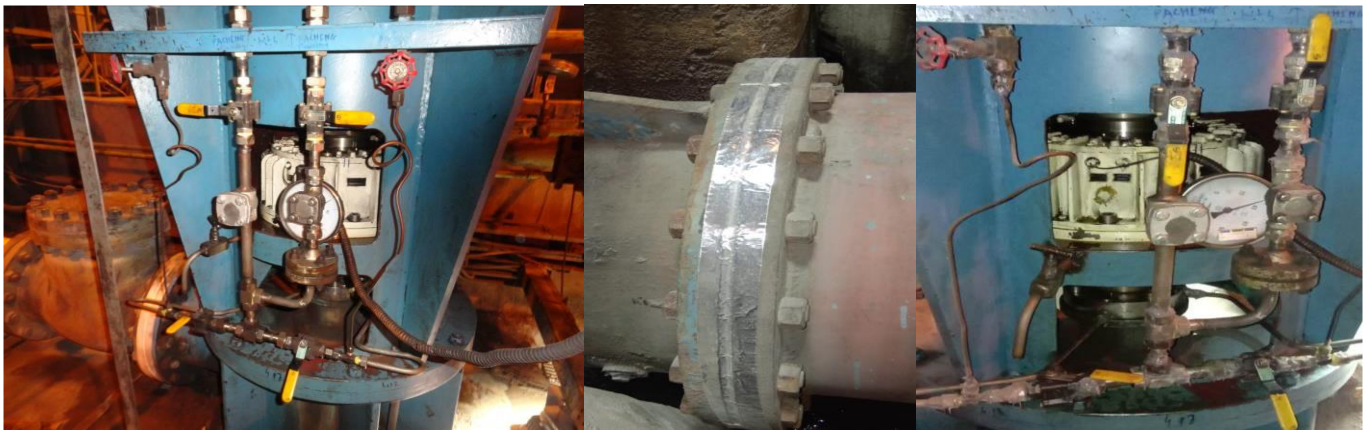

Figure 7 replaced with all new o rings, gasket in sealing system

II. RESULTS AND DISCUSSION

In many power plants using DM water for steam purpose, the purity of boiler feed water and steam is absolutely crucial; To prevent damage of steam drum ,deaerator, condensate and feed water piping due to scaling and corrosion, on line steam and water analysis of critical parameters such as pH, Conductivity, Dissolved Oxygen, Silica, Sodium, Phosphate etc. is a must. To keep the power plant up and running, with minimum erosion and corrosion of steam drum, deaerator and piping. Steam and Water Analysis Systems (SWAS) that provide exact, precise measurements on all these critical parameters as dissolved oxygen.

Modern portable devices such as the Orbisphere 3100 Oxygen Analyzer can be used as online calibration. The portable device is first calibrated against a traceable standard in the SWAS lab and is then used as a mobile reference throughout the plant. Because online analyzers have direct calibration functions, the calibration will take just few seconds with the portable unit connected at the same sampling location.

Figure 8 CEP DO and Deaerator DO measured in online reading in SWAS lab

In this scenario the traceability and link to external official standards is fully covered. The dissolved oxygen measurement has the benefit of long term stability, even when the measuring device is in stand-by mode. Any abnormalities in dissolved oxygen without operation do not affect the metrological properties of this working reference.

After modification of CEP measured Dissolved oxygen present given below table.

Dissolved oxygen			
Date	**Load in MW**	**CEP DO in ppb (< 20 PPB)**	**Deaerator DO in ppb (< 7 PPB)**
18.12.2018	175	7.3	06
19.12.2018	175	5.8	3.6
20.12.2018	299	9.5	04
21.12.2018	310	07	06
22.12.2018	224	08	05

Table 2 after modification of CEP measured Dissolved oxygen present in system

III. CONCLUSION

Deaerated oxygen levels cannot be maintained at start-up and low load," is no longer correct. The deaeration of water to a dissolved oxygen level of 5 ppb is difficult. However, this level of deaeration can be achieved through a combination of methods. Highly condensate dissolved oxygen levels of 20 ppb under the most adverse operating conditions. The operation condition is one of the most important parameters that influence the efficiency of the catalytic reduction of dissolved Oxygen. In this paper it is possible to reduce dissolved Oxygen by various corrective actions undertaken as well as proposed for future implementations are discussed and recommendations are provided for proper operation and maintenance.

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