Inspection methodology and upgrade options for Anode Bake Fume Treatment Centres

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Abstract

Fume Treatment Centres (FTC) are essential for the operation of anode baking furnaces and for keeping emissions within environmental limits. Many FTCs in operation today have exceeded their initial design life and experience severe operational and maintenance issues. This paper presents a structured methodology and risk-based approach which is used for assessing fit for service. Considering the uncertain future of carbon plants, smelters often seek to extend the safe lifetime by a given period. When addressing these challenges, a strategic choice must thus often be made involving building new, upgrading, refurbishing, or a combination. A key piece of equipment, where failures are critical, is the cooling tower. Repairs can often not keep up with deterioration, so it must either be replaced entirely or substituted by the AHEX (anode heat exchanger). The AHEX solution does not only provide gas cooling but also upgrades the reactor where alumina is mixed with gas upstream the filter house.

Keywords: Fume Treatment Centre, Cooling Tower, Corrosion, AHEX, Inspection.

1. Introduction

REEL provides solutions for the aluminium industry, alumina handling from port to pot, cranes, anode handling equipment, as well as Gas and Fume Treatment Centres (GTCs and FTCs) through its dedicated Environmental Control Solutions activity. For close to 50 years, REEL ECS has delivered more than 25 Fume Treatment Centers (FTC) around the globe, treating fumes from Anode Baking Furnaces (ABF). The REEL ECS team provides existing aluminium smelting plants with services relating to modernization, replacement, or capacity increase operations. Over the years, improvements have been made in technology mainly around dry scrubbing and cooling towers with water, and more recently the AHEX heat exchanger that omits water injection and enables energy recovery.

2. Aging of FTCs and ABFs

The installed base of FTCs is getting olde and this paper focuses on the challenges of aging plants, specifically the ones that are 25–40 years old and have surpassed their intended service life. It aims to explain some common challenges, the causes and how they can be addressed short term, and the possible upgrade options for more long-term operation.

Operation of the FTC and ABF are closely linked. After two to three decades, it is often observed very high fumes flow (Nm^3 gas per hour), due to leakages, and it is then not only time to rebuild the furnace but also to assess the state of the FTC. As the furnace is aging and refractory condition worsening, the demand for flow is indeed increasing.

In the meantime, the performance of the FTC must thus be kept up, by measures such as, monitoring the pressure drop across the plant, internal cleaning, increasing rate of bag filter replacement [1]. Constant suction from the FTC is vital for combustion efficiency and safety in the ABF [2]. Failing to maintain the performance of the FTC can cause loss of draft, quality excursion in anode production, and even lost aluminium production due to lost in-house anode production and difficulties with sourcing anodes from elsewhere.

3. Failure Modes

As all other technical installations, FTCs are subject to normal wear and tear in both electrical and mechanical equipment. As they get older, the maintenance frequency will increase. Smelters often observes a growing backlog of maintenance up to the point where the plant's reliability is at obvious risk. This article focuses on the gas treatment process and corrosion-related failure modes, especially those putting the gas conduit at risk. This is because failure of the ductwork will lead to loss of draft and in worst case be a risk to the structural integrity.

3.1 Acid Dew Point Corrosion (Internal to Gas Conduit)

Gases from the ABF contain various combustion products, refractory dust, coke dust, and tars, including PAH, SO_2, SO_3. Together with water weak and strong acids can be formed. The main protection of the duct is the insulation. Insulation is vital to ensure that all internal duct surfaces are maintained at around 100 °C especially where alumina is not present to reduce the acid concentrations. Lack of insulation can not only jeopardize the duct locally but also downstream equipment. Once holes in the ductwork start to develop, either through the steel walls or around expired expansion joints, cold ambient air enters, causing not only the draft capacity to decline, but also the process temperature to drop. The result is a vicious cycle where more air entering and the temperature dropping, loss of acid dew point margin, and accelerated degradation.

Another high-risk area is the cooling tower. It is critical that all the injected water is evaporated before reaching the bottom of the conditioning tower, if not the condition will quickly deteriorate from acid attack [2].

Major concerns arise when it is found that the loss of material in the gas conduit turns in to a risk to structural integrity. It is often found that problems in the plant are linked to the operation of the process. The risk for acid dew point corrosions varies with the temperature and SO_3 concentration in different locations of the plant (Table 1). Stagnant areas in ductwork, such as dead legs, are at higher risk. Understanding acid dewpoint corrosion is key to grasping the varying risk levels in different parts of the plant.

The sulfuric acid (H_2SO_4) dew point can be evaluated by correlations. Industry recognized ones are Okkes [3], Verhoff [4], and ZareNezhad [5]. The sulfuric acid dew point, a temperature, is a function of H_2O and SO_3 concentration in the gas. The reader should keep in mind that the ABF is operated with a high excess air, so fume and moisture concentrations are much lower than that found in power plants or other combustion processes, but challenges can still arise in the FTC.

Representative values for process temperature, moisture content, SO_3 concentration, and calculated acid dew point are shown in the column of table 1. Aim is to have a margin, where the steel wall temperatures are well beyond the predicted acid dew point temperature. In an insulated duct, wall temperature is close to that of the process temperature. If insulation is removed,

Figure 4. Three AHEX modules installed at TRIMET Hamburg [6].

6. Conclusion

FTCs are critical equipment, as they directly impact the quality, availability and safety of the anode production process. The condition of aging FTCs should therefore be assessed, and remedial actions implemented to prevent what can easily become major operational disasters. With this in mind, REEL ECS has developed a structured methodology to assess FTC condition, including both the process aspects as well as its structural integrity. Such assessments can then be used to prioritize areas to be addressed and select the most relevant approach between refurbishment or replacement of the affected equipment, in full or in part. Cooling towers representing the main area of concern, their replacement by AHEX – a heat exchanger-based solution developed by REEL ECS – can advantageously be considered.

7. References

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