Modern Fume Treatment Centers for Anode Baking Furnaces; A Comparison between Two Fumes Cooling Technologies

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https://doi.org/10.71659/icsoba2024-el012

Abstract

Fives Solios is one of the leading western suppliers of Fume Treatment Centers (FTC) for Anode Baking Furnaces (ABF) since the early beginning in 1980 with the largest installed base. All of these references are with water cooling towers to cool down the hot ABF fumes before dry scrubbing with alumina. These cooling towers (CT) are very efficient and long lasting but they use water, which is not only an increasingly scarce resource but also a cause of potential corrosion.

Norwegian Emission Abatement Technologies (NEATEC) has a world leading competence in the retrofit of FTC and GTC (Gas Treatment Centers) with TurboBed reactors and cooling of fumes with NEATEC heat exchangers (NHEX).

For the past 2 years, Fives Solios and NEATEC have developed a partnership on various projects bringing together the best technology from each company to build innovative solutions with high added values to their clients in term of performance and carbon footprint reductions.

One of them consists of implementing for clients having bad experience with cooling towers operation, a NHEX heat exchanger into the Fives OZEOS filter technology for FTCs. The NHEX, of tube and shell design, acts both as gas cooler and as reactor where tar components can condense on alumina particles that simultaneously adsorb HF and SO_2 before entering the filter. The TurboBed alumina injection ensures thorough and even alumina distribution in the flue gas upstream of the entry section of each heat exchanger.

The aim of this paper is to compare the NHEX and the cooling tower FTC solutions with advantages and drawbacks, CAPEX and OPEX, with and without heat recovery and make it fully understandable for our clients in order to facilitate their technology selection.

Keywords: Fume Treatment Center, Anode Baking Furnace, Fume cooling, Heat Exchanger, Water spraying.

1. Introduction

A Fume Treatment Center (FTC) dedicated to Anode Baking Furnaces (ABF) has two main purposes:

- To always ensure a specific flow of fumes draw through the ABF even when the burner ramps are stopped to allow furnace ventilation and avoid the stagnation of volatiles coming out of the anodes in the preheating zones of the ABF fires,
- To treat the polluted fumes generated by the joint combustion of:

- o The natural gas mainly (exceptionally fuel oil) in the burners to bake the green anodes and
- o The volatile compounds of the pitch present in the heated anodes during the firing process.

The main pollutants compounds in the fumes generated during the firing process of a modern ABF are dust, fluoride (gaseous and particular), SOx (SO_2 and traces of SO_3), tars and carcinogenic Polycyclic Aromatic Hydrocarbons (PAHs) compounds.

Consequently, the aim of a typical modern FTC with alumina as reagent is first to maintain a constant draft and under-pressure at the ABF outlet. Secondly, to clean the fumes from above pollutants to the lowest possible values before releasing the clean fumes to the atmosphere according to the following typical table based on the Best Available Technology (BAT):

Table 1. Typical modern ABF and FTC fumes characteristics [1].

	Typical ABF outlet	**Typical FTC outlet**
Fumes flow	5 000 to 5 500 Nm^3/t anode	+5 to +10 % on ABF outlet value
Fumes temperature	120 to 220 °C	Around 105 °C
Pollutants to be treated:		
- **Coke dust**	100 to 200 mg/Nm^3	< 5 mg/Nm^3
- **Condensed tars**	10 to 100 mg/Nm^3	< 1 to 2 mg/Nm^3
- **Gaseous fluoride (HF)**	10 to 200 mg/Nm^3	< 0.3 mg/Nm^3
- **Particulate fluoride (Fp)**	10 to 200 mg/Nm^3	< 0.3 mg/Nm^3
- **PAH:**		
• **BaP (as per BREF 2016)**	0.01 to 0.2 mg/Nm^3	< 0.001 mg/Nm^3
• **PAH16 according to EPA**	5 to 12 mg/Nm^3	< 2 mg/Nm^3
• **PAH16 according to NS**	5 to 12 mg/Nm^3	< 1 mg/Nm^3
- **SO_2 (if natural gas)**	400 to 800 mg/Nm^3	~25 % efficiency in Dry Scrubber (Up to 99 % if Wet Scrubber)

BaP (Benzo[a]Pyrene) is chosen by the BREF 2016 as a unique indicator for PAH control. BaP is one of the most toxic PAH for human beings and is part of the 16 PAHs in both EPA and Norwegian Standard (NS) lists.

The PAH 16 EPA (US) list includes, in addition to heavy toxic PAHs, the lightest ones as naphthalene, acenaphthene, acenaphthylene and fluorene, not included in the PAH 16 Norwegian Standard (NS). Dry scrubber efficiency on lighter PAHs is much lower than on heavy ones where it can reach up to 99.9 %. This is due to the lower condensation temperatures of the lighter compounds.

The SO3 content in fumes from closed type furnaces is much higher than from modern open type furnaces. It can reach up to 2 % of SO_2 content in closed type furnaces, while it seems to be much lower in modern open furnaces (<< 0.5 %).

To maximize the efficiency of the dry scrubber in terms of HF and PAH adsorption on alumina as per above table, fumes cooling is necessary prior to fresh alumina injection in reactors as per Figure 1. The capture of the fumes is achieved in the reactors and on the filter bags and further enhanced through recycling alumina from filter hopper to reactors.

It is ultimately local policies and experiences, the scarcity of water resources as well as the possibility of recovering effectively or not the heat with the aim of reducing significantly the FTC carbon footprint that will guide the final choice.

7. References

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