FLAWLESS CARBON JEWELS WITH XELIOS 2.0

Xelios 2.0, the latest Fives’ anode forming solution is designed to produce the best quality anodes.

Thanks to recent improvements, this ultimate machine allows for flexibility, reliability and consistently produce high density and defect free anodes.

Xelios 2.0 is the answer to customers eager to increase their anode density and to boost their smelter performance. It is easy to operate and it offers easy access, less maintenance and improved reliability.

Xelios 2.0 has been successfully implemented at Ma’aden Aluminium plant in Saudi Arabia. It will be soon started-up at Kitimat in British Columbia, Canada.

www.aluminium.fivesgroup.com
Green anode plant activities for aluminum smelters generate noxious vapors containing CTPV (Coal Tar Pitch Volatiles) – especially PAHs (Polycyclic Aromatic Hydrocarbons). Fumes collection and treatment prevent the release of these pollutants into the working environment and atmosphere. Traditional pitch volatile capture has been performed with coke injection followed by filtration (conventional dry scrubbers).

In recent years, RTOs (regenerative thermal oxidizers) have been used at some plants to improve PAHs destruction particularly on the lighter fractions characterized by their low boiling point. In order to increase destruction efficiency at lower operating costs, Fives Solios provides a dual approach based on the combination of a conventional dry scrubber and an RTO. In such an approach, the RTO is dedicated to hot pitch fumes, while the dry scrubber is dedicated to lower light PAH fraction emissions.

This combined solution is named Eolios and has been successfully installed in Mosjøen, Norway and in Qatalum, Qatar.

Performance of the Eolios Pitch Fume Treatment System

Coal Tar Pitch: The Source of PAH Emissions

Nature of PAHs

PAHs are the main components of coal tar pitch, used as a binder for the fabrication of anodes. To be used in the process fabrication of anodes, it is heated to become liquid and is mixed with pre-heated aggregates (Calcined Petroleum Coke) to obtain a homogeneous hot paste (160-200°C).

Upon reaching this temperature range, the coal tar pitch releases a high amount of CTPVs which are mainly composed of PAHs. PAHs can be divided into two groups: light and heavy fractions. The EPA regulation has identified 16 PAH molecules as priority pollutants to monitor, based on their carcinogenicity and occurrence, including naphthalene whose carcinogenicity for human health is today contested by some studies. The OSPAR regulation only monitors 11 PAH molecules, which are mainly the heaviest PAHs, i.e. the most carcinogenic ones.

PAH Emissions in the Fabrication Process of Anodes

In paste plants, PAH emissions occur in all areas where coal tar pitch is used or stored at a high temperature. The main areas affected by these emissions are the paste mixer, the paste cooler and the anode forming area.

The proportion of light PAHs appears to be 70% of total emissions, compared to around 30% for heavy PAHs.

The anode paste cooler equipment has been introduced in the anode fabrication process to improve anodes density. Using water to cool down anode paste lowers the partial pressure of PAH vapors generated by the paste, thus realigning the equilibrium towards the production of light PAH fractions.

Consequently, adding water into the paste cooler drastically increases the amount of light PAHs. This phenomenon was first confirmed at the Alcoa Deschambault paste plant, (Canada) where light PAH emissions were multiplied by six after paste cooler installation.

Conventional Coke Dry Scrubbing System

The dry scrubbing system is derived from the potline alumina dry injection scrubbing technology. This treatment system was developed by Fives Solios in 1977, and has been installed since then in more than 70 plants in the world. It consists of injecting coke fines in a gas stream loaded by pitch fumes: causing an adsorption phenomenon to occur between the coke and pitch fumes. Then, the fines fraction of coke, readily available for the preparation of the anode paste, is injected counter-currently to the fume-laden stream. Turbulence and highly efficient contact between the pitch fumes and aerosols are thus promoted inside a Venturi reactor. Pitch loaded fines are then collected through the dust collector and reintroduced into the anode paste recipe with their condensed hydrocarbons. Finally, the clean gases are released to the atmosphere through a discharge stack.

The global PAH capture efficiency of dry scrubbing varies between 90% and 98%, depending on the treatment temperature and the list of PAHs involved.

This efficiency ratio is higher for heavy PAHs. For these components, the common efficiency is about 99.5%. The dry scrubbing system philosophy is based on the ability of PAHs to condensate when establishing contact with coke fines inside the reactor: this allows their adsorption on the surface of coke fines. That explains the higher efficiency of the process on heavy PAH fractions, which condensate even more easily in comparison to the lighter PAHs. The most toxic PAHs being the heaviest fractions (B(a)P or equivalent), they are extremely well handled by conventional coke dry scrubbers.
RTO: New Technology for a Better Destruction of light PAHs

The RTO Principle

PAHs, mainly composed of C-H bonds, are easily broken by oxidation as follows:

\[ \text{CaH}_{2a} + \frac{(a+b/2)}{2} \text{O}_2 \rightarrow a\text{CO}_2 + b\text{H}_2\text{O} \quad \text{Heat} \]

The oxidation temperature is about 850-900°C, depending on the nature of PAHs. Good combustion practices include management of the “3Ts”: Temperature, Turbulence and Time.

RTO Description

The RTO is a compact equipment composed of 3 main elements:

- **The combustion chamber**, where the oxidation reaction takes place
- **Ceramics beds**, used as heat exchangers: which store and recover heat to preheat the inlet gas flow, allowing for energy savings,
- **The valve box**, which includes two valves to isolate inlet & outlet duct fumes and one purge valve per chamber.

Eolios at Qatalum Paste Plant: An Innovative Solution for Optimum Emission Performances

Stringent emission requirements have led Fives Solios to install the Eolios system to treat coal tar pitch fumes.

The high concentrated fumes collected from the paste cooler, which contain mainly light PAH fractions and water vapor, are specifically treated by an RTO unit. Fumes emitted by the remaining pieces of equipment (mixer, vibrocompactor, etc.) are treated by a dedicated dry scrubber.

A set of FID (Flame Ionization Detector) measurements were performed in order to estimate the relationship between RTO temperature and destruction efficiency. The FID measures the concentration of Total Volatiles Organic compounds and they show clearly that a higher combustion temperature enhances RTO efficiency due to an increase in organic compounds destruction: 91.2% efficiency measured at 840°C against 96.2% at 870°C.

Once the system was fine-tuned, performance tests were undertaken at the main stack by a third party. PAH emissions were measured as per ISO 11338-1-1 standard.

Results display a 0.96 mg/Nm\(^3\) concentration for 16 PAH (Norwegian Standard 9815) corresponding to a global destruction efficiency for the Eolios system of 99%. This value sets a new benchmark for Eolios designed without pre-filter.

Eolios at Mosjøen: Good Results after 6 years

Fives Solios supplied its first Eolios at Alcoa Mosjøen Aluminium Smelter in 2007.
On this reference, the ventilation of the green anode plant is split into two separate lines: the wet fumes line, treated with a dry-scrubber followed by the RTO and the dry fumes line, treated with a dry-scrubber only. These two lines are implemented in parallel and join each other at the stack.

On both lines in-line coke injections are installed which allow for the catching of pitch vapors on the coke fines close to the location of emissions. The dry line generates a low concentration of pollutants mainly taken in charge by a Venturi reactor with coke injection followed by filter bags. The wet line collects much more gaseous tars and PAHs treated by RTO associated to a pre-filter with coke injection.

Eolios performance has met the PAH plant requirements of 0.05 kg/h (NS 9815) or 0.8 mg/Nm³ for the whole plant.

The first important maintenance intervention on the RTO appeared after 6 years operation. Regarding the dry-scrubber, regular preventive maintenance has ensured the correct running of the plant over this whole time.

The introduction of the RTO in the Eolios technology can raise a question about the possibility to use it for all paste plant streams.

The advantage of such a configuration is to have a diluted stream that is optimal for RTO operation. However, as the RTO is more efficient on light PAHs, the global destruction efficiency for PAHs in whole (light and heavy) is limited at 95%. This limited efficiency is due to the adsorption/desorption phenomenon of heavy and intermediate PAHs that occur in heat exchangers during a cycle. This configuration seems totally unable to achieve the 99% efficiency observed with Eolios at Qatalum and Mosjøen Paste plant.

An alternative to the full RTO is the Hybrid RTO which conveys highly concentrated streams directly to the combustion chamber via a specific burner.

The energy consumption for such configurations (full RTO and full Hybrid RTO) is another parameter to take into account: A more diluted stream decreases pitch fumes concentration, taking the RTO away from auto thermal mode. A full RTO of 50,000 Nm³/h, requires around 100 m³/h of gas, whereas a RTO integrated in the Eolios technology will only consume about 20 m³/h of gas. The hybrid RTO requires even higher gas consumption, up to 120 m³/h (hybrid flow rate: 3,000 Nm³/h & main RTO inlet: 27,000 Nm³/h).
Moreover, the flow rate passing through the heat exchanger is used to size the RTO. RTO dimensions will increase with flow rate, therefore considerably increasing CAPEX.

In both configurations, the system (full RTO and hybrid RTO) cannot benefit from the biggest asset of Eolios: flexibility. RTO direct by-pass to the atmosphere does not exist in the Eolios solution, as the RTO by-pass is directed to the dry-scrubber. It means that pitch fumes are at least treated by the coke dry-scrubber in case of an unexpected problem that would require stopping the RTO. This offers an attractive possibility to switch on the dry-scrubber by-pass which remains quite “clean” in terms of emissions. This is very comfortable for operation.

Whereas a direct by-pass must be used at the strict minimum in case of emergency, Fives Solios by-pass including fumes treatment can also be used during maintenance or operation. An RTO has important inertia due to its ceramics and can be protected, using the by-pass, from abrupt and impetuous variations at the inlet. Therefore, any of these variations can be absorbed by the coke dry-scrubber and keep the RTO ready to run on dirty fumes without delay when the problem is solved and inlet conditions are back to normal operational ones.

Last but not least, Eolios offers a higher treatment capacity. To limit full RTO CAPEX, RTO suppliers tend to reduce the treated flow rate as much as possible, where temperature is high enough for condensation problems. Eolios does not need to heat fumes on its dry-line, as coke injection of the dry-scrubber adsorbs tars at an ambient temperature. It is quite interesting to be able to increase ventilation of the paste plant, as the possibility to treat more air with same inlet data is directly linked to safety issues (ambient air quality in paste plant). The possibility to increase the treated air flow is also useful for revamping considerations and much easier to perform on Eolios than on a full RTO solution.

Conclusion

Environmental emissions treatment requirements are becoming more and more stringent, especially for suspected carcinogenic substances such as PAH’s from pitch vapor. Dry scrubbers remain the most efficient technology to treat heavy PAHs, however the introduction of an RTO to treat lighter PAHs is a radical improvement for the whole pitch fumes treatment system.

The Eolios solution, which combines dry scrubbing and an RTO, allows operation of the green anode plant while maintaining PAH emissions at a level below such stringent requirements. Eolios exhibits a lower operating cost and a smaller carbon footprint than alternative technologies, such as full RTO for instance, while providing very comfortable flexibility of operation thanks to its convenient by-pass to dry-scrubber.

The implementations of Eolios at Mosjøen Paste plant and recently at Qatalum Paste plant confirm the benchmarking performance and benefits associated with this technology.

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<tr>
<th>EOLIOS</th>
<th>Full RTO</th>
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<tr>
<td>RTO: 5 000 m³/h</td>
<td>RTO: 50,000 m³/h</td>
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<tr>
<td>Dry Scrubber: 45,000 m³/h</td>
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**PAH16 Destruction / Capture Efficiency (NS9815)**

- 97/98% (Proven)
- 1 mg / Nm³ (Measured)

- 95% max guaranteed
- >5 mg/Nm³ (Published)

**By pass: treatment by the DS during RTO maintenance**

- By pass not possible; = redundancy required or prod. Stoppage

**Natural Gas Consumption**

- <20 m³/h (44,000 €/year)
- 100 m³/h (220,000 €/year)

**CO₂ Emissions**

- 170 T/Year
- 850 T/Year

Full RTO vs Eolios