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Opening photo: **Rotary concentrator + RTO system.**

INNOVATIONS: PRESENT&FUTURE

Pollutant Emission Control in Industrial Coating Processes

Ruggero Baldi

Airprotech Srl – Magenta, Italy ✉ r.baldi@airprotech.eu

There are various types of harmful substances that can be released into the environment by coating and surface protection processes – solid substances and particles such as paint powders, crystallised substances, gaseous volatile compounds VOC, solvents, chemical additives, and others, depending on the specific type of process. Solid-state substances like particles and dust can cause significant and short-term damage at the bronchial and pulmonary levels; volatile organic substances can have even more serious consequences, with high incidence on cardiovascular diseases and tumours.
The main objective of the ventilation and pollution abatement systems intended for

industrial coating and surface protection plants is guaranteeing the work areas' healthiness, in order for both permanent and occasional employees operating near these machines to find adequate working conditions in terms of safety and health, in compliance with the regulations in force on the permitted concentration limits.

Environmental ventilation and fume extraction

Ventilation and fume extraction systems are generally composed of a series of aspiration hoods that collect the fumes and substances generated by industrial processes and convey them outside the work environment, in order to ensure adequate ventilation of the different areas. The purpose is to suck such volatile particles or substances and prevent them from spreading inside the plant, with harmful consequences on operators and surrounding equipment. The choice of the type and size of a suction and ventilation system, first of all, calls for the identification of all areas where pollutants and dust are generated and emitted, as well as for the analysis of pollutants and their concentration. Then, the extractor hoods or modules' type and size are selected to guarantee the aspiration of substances without affecting or interfering with production processes. Finally, the complex system of channels and pipes that transfer the particles or pollutants outside the work environment is designed. Various parameters such as the static pressure at the suction points, the speed of the gases inside the channels, and the pressure losses generated on the way to the gases' final release point are taken into consideration. Moreover, partitioning systems and valves are often installed on the channels, in order to allow independent adjustment of the volumes sucked by each channel and thus balance the system by ensuring adequate suction at each point.

Control of emissions and abatement of pollutants

The selection and installation of an adequate ventilation and exhaust system for fumes and gaseous effluents produced by coating and surface protection processes represent the first intervention phase.
The second but equally important phase is the integration of an emission control unit, including an adequate system for the abatement of the polluted substances conveyed out of the work area. As already mentioned, there exist reference regulations that establish the pollutant emission limits allowed. Such limits are set according to the specific processes and pollutants involved. Several technical and plant engineering solutions have been designed for the different needs of various production and coating processes, all with the goal of minimising the amount of pollutants that are released into the atmosphere through the chimney. The technical solutions differ according to the specific pollutants to be treated, i.e. solid particles or gaseous substances such as volatile organic compounds VOC or volatile inorganic compounds VIC. In specific cases, integrated solutions are also available in which different technologies are used one after another to cope with all possible cases and collect all pollutants, even with different natures. The design of pollutant abatement plants should take into account both technical and cost requirements, including investment and operating costs.

Figure 1: **A Venturi scrubber-type wet filtration plant.**

Powder coating plants

In the case of powder coating plants, the ventilation system's task is sucking in as much excess paint (i.e. not deposited on the products) as possible. The first stage usually performed by this type of plant is a pre-filtration process with disposable filter panels. The characteristics of the system, such as material and permeability, are selected according to the type and concentration of powder in the fumes.
In applications where the excess paint sucked by the ventilation system is dry, the final filtration unit is generally composed of a cartridge fabric filter or filter sleeves. In some cases, the fabric filter is combined with cyclone systems for pre-separation. Both cartridge filters and filter sleeves are often integrated with an automatic filter cleaning unit that extends their service life.
If the ventilation system must handle a sticky powder due to the type of paint used, fabric filters cannot be used, since the fine powder would irreversibly stick to the surface of the filtering elements thus making them useless in a short time. Wet filtration systems such as Venturi scrubbers are installed for these applications (**Fig. 1**). Venturi scrubbers-type wet filtration systems are used to remove solid particles from gases through interaction with water. The type and size of the system depend on the characteristics of the powder and particles to be treated, i.e. their quantity, concentration, granulometry, density, composition, and wettability.

Figure 2: **Active carbon system.**

Liquid coating plants

With liquid coating plants, the aspiration system must remove the greatest possible amount of vapours and gaseous substances generated within the machine. Also with this type of plant, disposable filter panels can be used for pre-filtration in order to collect any solid particles and dust in the fumes. Typical pollutants generated by liquid coating processes are volatile organic compounds VOC and, in general, solvents contained in the paints, which require adsorption, pre-concentration, or thermal oxidation abatement systems.

In the case of flows with a low concentration of pollutants (less than 300 mg/Nm^3), the simplest and most commonly used solution is the adsorption of pollutants through "disposable" activated carbons (**Fig. 2**). These plants require the use of different types of activated carbon as adsorbents for the removal of pollutants. Removal occurs through adsorption phenomena based on the surface interactions between contaminants and the surface of activated carbons. The gaseous effluents pass through the activated carbon bed and pollutants are adsorbed on the surface of the material, thus saturating the activated carbon bed itself; the clean gas is then released into the atmosphere. The carbons are progressively charged with volatile organic substances and they must be replaced periodically.

When the concentration of pollutants is up to 1000 mg/Nm^3, the most suitable solution involves the installation of a rotary concentrator with zeolite elements combined with a regenerative thermal oxidiser (RTO, **ref. Opening photo**).

The air to be treated in the rotary concentrator, containing a medium-low concentration of volatile organic compounds VOC, is purified in the concentrator consisting of a zeolite rotor and expelled into the atmosphere; downstream of the concentrator, VOC are concentrated into an air flow up to 20 times lower than the initial one. The high concentration flow leaving the rotor is fed by the combustion unit, sized for a limited flow rate where solvents are completely removed.

In the case of pollutant concentrations higher than 1000 mg/Nm^3, it is possible to install a regenerative thermal oxidiser (RTO) that can reach the optimal condition of auto-thermal operation. This guarantees minimum consumption of the support gas, exclusively used for the start-up and heating processes (**Fig. 3**). RTOs are specifically designed to eliminate pollutants from process gases through high temperature thermal oxidation. The chemical energy contained in these pollutants is transformed into thermal energy to favour the combustion itself. It is therefore possible to recover up to 96% of the heat produced by the VOC and support fuel combustion reaction, thus significantly reducing plant management costs.

Aluminium anodising plants

Anodising plants for aluminium products are composed of tanks containing different chemical products that perform the surface finishing process combined with the presence of colours and the electrostatic action.

In this special process, vapours and fumes are released in the environment full of volatile inorganic compounds VIC, which must be sucked in and treated with cleaning towers and, possibly, chemical reagents. Cleaning towers are used for the removal of volatile organic (VOC) and inorganic compounds VIC, which are soluble in water or in aqueous solutions with suitable chemical reagents that make one or more components of a gas mixture change from the gas to the liquid phase. The size of the plant and the type of chemical reagent depend on the chemical composition, concentration, and solubility of the pollutants to be eliminated.

Figure 3: **A regenerative thermal oxidiser (RTO).**