ecoDry

The process principal of the *ecoDry* system is centered around the concept of drying in a closed steam loop, with ~~a~~ process-integrated thermal oxidation. The separation of flue gas from the drying gas has the benefits of indirect drying (e.g. no contact between flue gas and material to be dried, free choice of fuel), along with those of direct drying (e.g. no hot surfaces, large free cross-sections), which are combined and used to the best possible advantage.

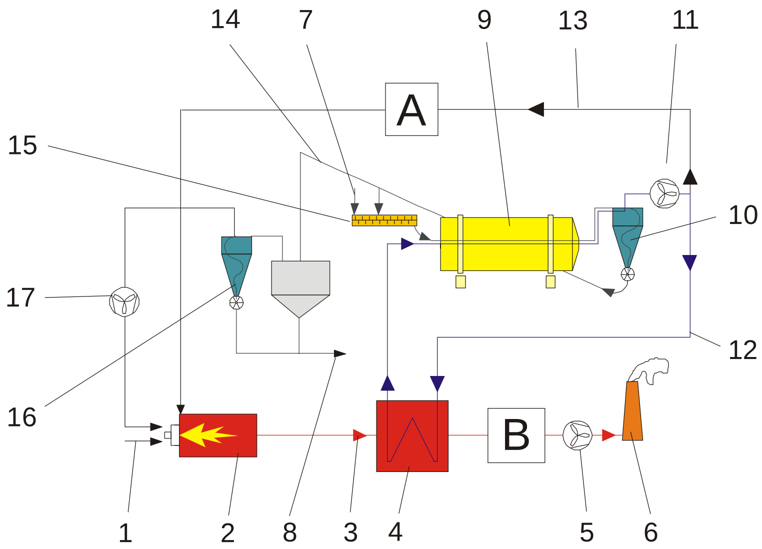

Figure 1 - Process Diagram *ecoDry*

1	Burner (gas, oil, solid fuels)
2	Furnace
3	Flue Gases
4	Heat Exchanger
5	Flue Gas Fan
6	Exhaust Stack
7	Wet Feed
8	Cooled Product
9	Rotary Drum Dryer
10	Cyclone
11	Main Fan
12	Closed Steam Loop
13	Bleed-Off Steam
14	Hot Dry Product
15	Mixer
16	Product Cooler and Cyclone
17	Combustion Air Fan

Energy Recovery by Vapour Condensation at:

A	Belt Dryer, Gas-Heated Evaporator, etc.
B	Belt Dryer, Evaporator, Heating, Heat Exchanger, etc.

General Process Description

Recirculating gases used for drying (12) are heated in a specially designed gas-gas heat exchanger (4) by combustion flue gases (3), and fed to the drying drum (9). In the drying drum, heated recirculating gases drive off the water contained in the wet product released during the drying. In the cyclone (10) this is separated from the product once again and taken back to the heat exchanger via the main fan (11) where it is reheated. Except for unavoidable infiltration at the product feed to the drum and the rotary valve, this recirculating gas cycle is optimally sealed, allowing operation at atmospheric pressure with superheated steam at a dew point of up to 95°C , which reflects a high water vapor-to-air ratio.

Via the bleed-off (13), a certain amount of steam for system energy control is removed from the closed loop and is incinerated as secondary air in the furnace combustion chamber (2). At combustion temperatures of approximately 870°C, contaminants such as dust, VOC's and CO are oxidized, thereby reducing emissions and odors at the exhaust stack discharge. The energy released in the process, together with the flue gases is available for the drying. Separating the generation of energy from the drying cycle results in a significant reduction in exhaust air volume as compared with conventional dryers. Due to the high percentage of water vapor, the closed loop steam gas density is low and the heat content is high, resulting in a reduction in electricity for the entire plant.

Emissions Reduction

Until now, emissions and malodorous exhaust gases from industrial drying plants have been reduced through the use of a combination of various downstream secondary processes. These exhaust gas purification systems are not only maintenance and cost-intensive, they represent additional emission sources due to the consumption of valuable resources (water, electricity, fuel etc.). Separation systems developed for purification of drying plant exhaust gases typically serve only to reduce particulate matter (e.g. scrubber systems, wet electrostatic precipitators). Gaseous organic odors and pollutants are not eliminated, or only partially so. Effective reduction of these components is generally only possible via the use of a thermal, chemical or biological oxidation stage. Utilizing downstream thermal processes (RTO, for example), it is possible to reduce the energy requirement by means of regenerative technology. As a result, contamination hazards such as dust and ash often requires that a preliminary, efficient separator be installed as well. The additional loss of gas pressure, as well as operation of pumps, filters and other components, result in a significant net increase in operating energy required for plant operation.

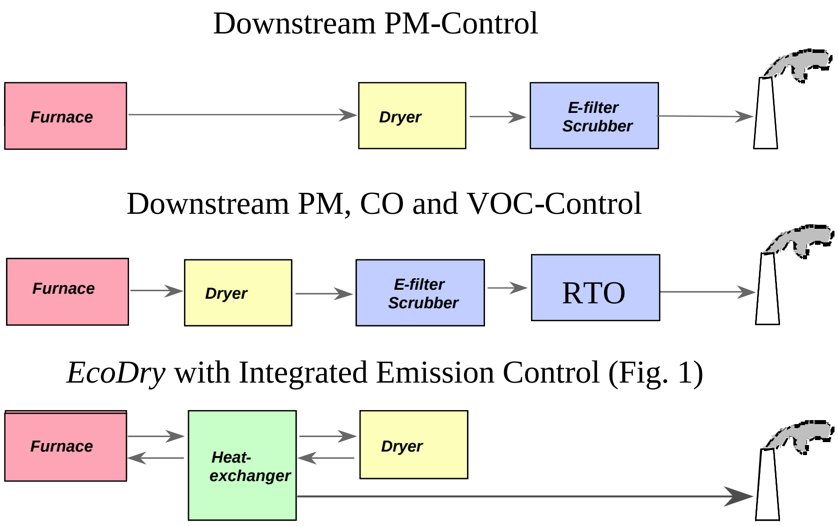

Figure 2 - Emission reduction process

When drying in a closed gas cycle (***System ecoDry***), a reasonable alternative is the thermal oxidation of dryer vapors as an integral part of the overall process. This means that with ***ecoDry,*** additional post treatment of the exhaust gas can be eliminated, energy and operating materials can be conserved, and plant downtime can be reduced by keeping essential maintenance to a minimum. Moreover, the energy released by oxidation is also used in the drying process.

Note:
If, as indicated at point A (see Fig. 1), energy recovery is realised by condensing the dryer vapors in auxiliary equipment, such as an evaporator or belt dryer, it is also possible to introduce exhaust gases from other processes to the thermal post-processing. The maximum mass flow rate for these exhaust gases is determined by the mass and energy balance of the ***ecoDry*** furnace.

Energy Recovery

During the dehydration (drying) of wet materials, the normal method is to employ indirect or direct primary heat, in order to expel (evaporate) water from the product. Depending on the drying process, efficiency, in per pounds of water evaporated per units of primary energy used, will be different. It will always, however, lie above the latent heat of water (the energy required to evaporate 1 lb water at a specific pressure), with this proportion normally accounting for in excess of 80% of the entire energy input. If drying is viewed in isolation, the efficiency comparison of two systems (with the exception of electrical energy input) with respect to primary energy use per pound of water evaporated becomes necessary and the resulting water vapor is released to the environment via the exhaust stack.

If drying is considered part of an integrated overall energy system, there is, in some cases, an opportunity and need for energy recovery, if this can be done cost-effectively and at an appropriate processing temperature. From the above perspective, it follows that efforts must be taken to condense the evaporated water since this represents the greatest potential in terms of available energy, i.e. latent heat of water vapor. If two drying processes are compared in an integrated overall energy system, it is necessary, in addition to the primary energy efficiency level, to consider the energy recovery efficiency level as well. The best value for this comparison is the dew point of the dryer vapors, since this is a reflection on both the gas temperature, and more importantly, on the *quality* of energy available. It therefore follows that the higher the dryer vapor dew point, the higher the energy recovery potential.

Figure 3 depicts a dew-point curve at atmospheric pressure along with typical operating points for varies drying system. The high water-to-air ratio (X-axis) of the ecoDry clearly indicates its advantages in reaching a higher dew point (or wet bulb temperature).

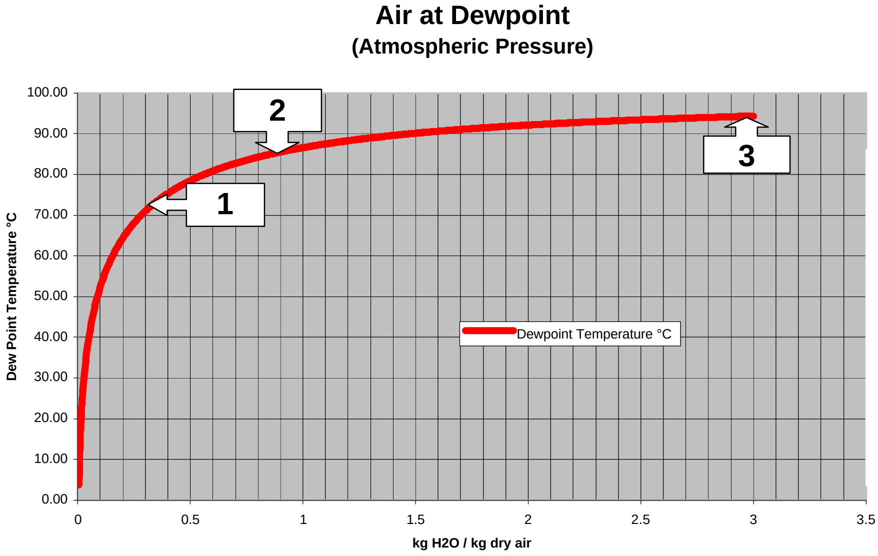

Figure 3 - Dew-Point Curve

In an *ecoDry* system with a primary energy input rate of approximately 1200 BTU per pound of water evaporated, and a dew point of up to 95 °C in the bleed-off gas at point A (see Fig.1), it is demonstrated that optimum operating values are achievable in both areas of energy use and efficiency.

It can therefore be stated that by cooling and condensing of the bleed-off steam, a substantial portion of its latent energy can be extracted in further processes (Fig.1 Item A), such as pre-dryer, evaporator, media heating, etc.

If warranted and economically feasible, it is also possible to utilize the residual energy of the exhaust gases (Fig.1 Item B) in additional processes, resulting in achievement of the optimum energy efficiency of the overall plant.

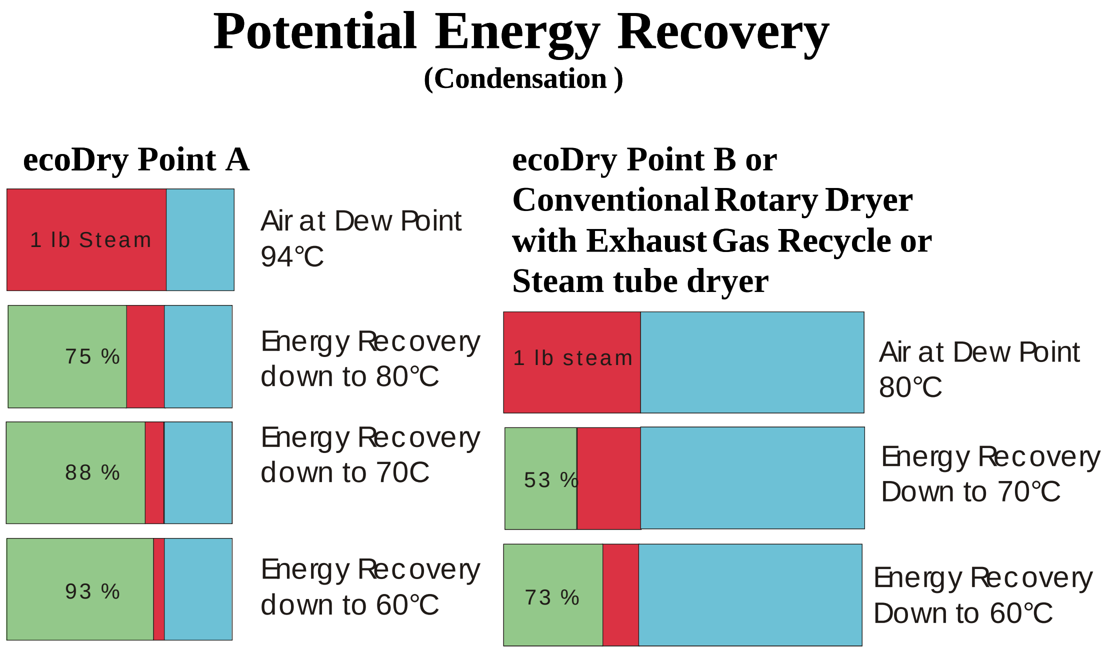

Figure 4 - Energy Recovery through Vapor Condensation

The ***ecoDry*** process represents a technical solution that successfully reduces emissions from an industrial drying plant without the use of additional downstream systems, resulting in greater overall drying plant economy through creative and efficient energy use and recovery.

Special Considerations for By-products of Fuel Alcohol and Starch Production:

In order to prevent sticking of the wet material at the entry to the drum, dried material must be recirculated during the drying of by-products (14, Fig. 1). Here, it is of great importance that wet material is optimally mixed with recirculated dry product; otherwise the resulting product will lump and become difficult to dry evenly, additionally resulting in lower product quality. For this reason, the ***ecoDry*** in this application has been expanded with an integrated high-speed mixer, which has been optimally adapted to suit this particular process. The mixer not only optimally mixes the various product flows (wet product, dry product, and syrup / CSL), but also effectively prevents the occurrence of product lumps through its function as a disintegrator.

If, as a result of process malfunctions prior to drying, the composition and thus the behaviour of the wet material changes (primarily increased stickiness), the system is designed with two modes to respond to such conditions: 1) the dry product recycle system is-configured such that material flow can be manually increased up to the absorption limit; and 2) the drum drive is equipped with torque measurement that responds to drum load changes which result from sticking at the drum inlet, and requiring operator intervention (increase in the recirculation volume, reduction of syrup / CSL flow, etc.). In general, it should be noted that due to a well developed drum design (one-way media flow, large cross-sections), combined with the above operator response tools, the risk of drum blockage due to obstructions or agglutination is significantly reduced, with diminished performance rarely encountered.

A further important point that should be considered when drying by-products of fuel alcohol and starch production, concerns arise with certain behavioral properties of the product being dried. Most important is the tendency for loss of flow, along with possible spontaneous ignition if cooling fails to occur prior to intermediate or final storage. In order to address such circumstances, the ***ecoDry*** design for this application was enhanced with product cooling as an integral feature in the process. Heat is removed in the cooler via counter-current air flow, providing the maximum cooling power with the lowest required air volume. Because the cooler air is heated by the product, which additionally is contaminated by residual product particulates upon exiting a scrubbing cyclone, this preheated air is subsequently taken to the ***ecoDry*** as primary air for use in furnace combustion, where emissions are thermally post treated.

Summary

The most important aspects of the ***ecoDry*** are summarised below:

- **Proven technology**
- **Low energy consumption**
- **Low emission values (within EPA permit limits)**
- **High energy recovery potential**
- **Process-integrated wet product preparation (mixer, disintegrator)**
- **Process-integrated dry product cooling**
- **Possibility of reducing emissions in the exhaust gases from other processes**