UPSTREAM PARTICULATE REMOVAL FOR RTOS ON DIRECT-FIRED OSB DRYERS – HOW MUCH IS ENOUGH?

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ABSTRACT

Since 1994 Regenerative Thermal Oxidizers (RTOs) have been applied to direct wood-fired OSB dryers for the purpose of VOC abatement. In early direct wood-fired OSB dryer applications many OSB producers felt that upstream particulate control was not necessary. However, the ash from the combustion of wood waste created a host of new operational problems for the RTO systems. This paper provides assembled historical particulate data and the correlation of these data with heat exchange media life in a downstream RTO. Only RTO units with random ceramic saddles were evaluated. The resulting trends showed that solid particulate levels in the range of 0.005 gr/sdcf (11.5 mg/Nm3) were necessary for a ceramic bed life of five years or more. The most important recommendation is to insure that the upstream particulate control technology be properly maintained for maximum particulate collection in order to minimize operational problems with downstream RTO systems.

INTRODUCTION

Prior to 1994, RTO technology had not been applied to direct wood-fired OSB dryers for VOC control. The direct-fired dryer was an entirely new application that posed new problems for RTO technology. The most costly problems were associated with the solid particulate emissions from the combustion and drying processes. In the early period of this application, there was no historical information available to help the OSB producer or the RTO supplier decide how much upstream particulate removal is necessary to allow trouble free operation and a long service life for the RTO. Today, approximately six years later, there is information available to aid in this decision.

This paper will discuss the nature of the problem, the mechanisms involved, and the potential solutions. In addition, historical data for RTOs using random packed ceramic saddles as heat exchange media will be presented to illustrate trends between inlet particulate levels and the longevity of ceramic heat exchange media.

PARTICULATE EMISSIONS FROM A DIRECT WOOD-FIRED OSB DRYER

Particulate emissions from a wood dryer are measured using US EPA Method 5/202. This method segregates the emissions into two categories: 1) filterable and 2) condensable particulate. The condensable, or back half, particulate is comprised of organic vapors that will condense at temperatures down to 68°F (20°C) using Method 202 (1). The analytical methods may vary somewhat from state to state. Regardless of any differences in analytical methods, these condensable particulate emissions are of little concern to the downstream RTO. This is because they are either organic compounds in the vapor phase or condensed organic vapors depending on the gas stream temperature entering the RTO. These organic vapors are oxidized within the RTO. They do, in fact, contribute as fuel to the process gas stream “solvent load” entering the RTO thus reducing natural gas consumption.

The level of filterable or front half particulate load, on the other hand, is a very important factor in the operation of an RTO. Filterable particulate is that which is collected on a glass fiber filter held in a filter holder heated to a temperature of 248 +/- 25°F (120 +/- 14°C). The glass fiber filter is 99.95% efficient on 0.3 micron dioctyl phthalate smoke particles1. Thus, for practical purposes the filter captures all of the solid particulate.

The filterable particulate from a direct-fired OSB dryer has a particle size distribution that is typically bi-modal. There is a component of large particles and a component of very small particles. The larger particles are either those produced in the rotary drum dryer by mechanical action or large fly ash particles from combustion that are not collected in the cyclone or multi-cyclone collectors. The efficiency of these devices determines the magnitude of the large particle component.

The small particle component is primarily composed of oxides of commonly occurring metallic elements such sodium, potassium, magnesium, calcium, and silica with smaller amounts of aluminum, iron, and zinc. These oxides are formed in the combustion process. At flame temperature they are vaporized into a gas then rapidly condense into a sub-micron particle or fume. Due to their small size, they easily penetrate the rotary drum dryer, the product recovery cyclone, and the multi-cyclone (if there is a multi-cyclone in the system). Unless they are removed by an additional particulate collection device, these oxides of alkaline earth metals will enter the RTO.

THE PROBLEM

The total particulate loading described above creates two major operational problems with the RTO. The first problem is created by the larger particulate that will deposit in the heat exchange media bed of the RTO. Over time this deposition causes plugging of the media bed with an attendant rise in pressure drop. When the increase in pressure drop across the media beds exceeds the capacity of the induced draft fan, operational problems for the entire dryer train develop. These include loss of dryer throughput, cyclone plug ups, and increased potential for dryer fires.

The only solution for these symptoms is wash out and/or bake out of the media bed. These involve costly down time for the dryer system. Over time, the frequency of wash out and/or bake out increases until the only viable solution is a complete media change out. Experience has shown that the wash out frequency in severe plugging situations can increase to once every two weeks with a bake out during the week between. This is a very costly endeavor in both time and expense.

Figure 1
Fused media, left, and new media, right.

The second problem is created by the sub-micron fly ash emissions. The impact of this emission is also on the heat exchange media bed. Due to the small aerodynamic size of the fly ash particles, they penetrate deep into the ceramic heat exchange bed where the temperatures are high. The top two or three feet of a ceramic saddle heat exchange bed are normally in the range of 1,300 to 1,400°F (704 to 760°C). The oxides of potassium and sodium (the most troublesome and abundant alkaline earth metals in wood dryer exhaust) have a melting point in the range of 1,200°F (649°C). Therefore, in the upper part of the bed these oxides tend to melt and fuse to the ceramic saddles. In the liquid state they react readily with the silica based ceramic material commonly used for heat exchange media. This results in loss of strength and crumbling of the media. The fusing and ultimate crumbling of the media results in increased pressure drop and the associated dryer train problems. The photograph in Figure 1 shows an example of fused media in its early stage of degradation as well as new ceramic saddles.

SOLUTIONS TO THE PROBLEM

Various types of particulate collection devices have been applied to direct-fired OSB dryers; some marginally effective and some more effective. In addition, some OSB producers have elected to run RTO systems with no control beyond the primary cyclone or secondary multi-cyclone. This results in a wide range of particulate loading conditions for the gas streams currently entering RTO systems in this industry.

These particulate loadings can be generally placed into three broad categories. The highest particulate load would be from those dryers with no additional particulate control. Depending on how the dryer is operated (inlet temperatures, throughput, efficiency of cyclones, etc.), the particulate concentrations entering the RTO can range from 0.08 to 0.25 gr/sdcf (183 to 571 mg/Nm3).

The next category is for dryers with low to medium-efficiency particulate control devices on them. These include different types of dry collectors and low efficiency wet electrostatic precipitators. The particulate concentrations entering the RTO can range from 0.02 to 0.08 gr/sdcf (46 to 183 mg/Nm3).

The last category is for dryers with high efficiency particulate collection devices to protect the RTO. The only proven technology in this category is a high efficiency wet electrostatic precipitator. The particulate concentrations entering the RTO are less than 0.01 gr/sdcf (23 mg/Nm3).

RTO MEDIA BED LIFE – EXPERIENCE TO DATE

The question of how much particulate removal upstream of an RTO is necessary to allow long term RTO operation has been asked since the first unit was applied in this industry in 1994. Since the industry has only a little over six years experience with this application, there is a long way to go. However, there is some information available and with this information we are beginning to see a trend. On the basis of wet ESP/RTO systems Geoenergy has been involved with, we have developed the curve shown in Figure 2.

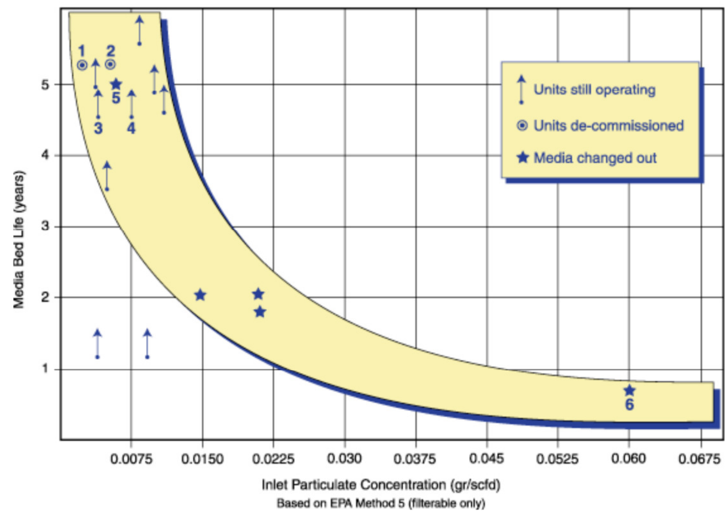
All data points shown in Figure 2 represent filterable particulate concentrations (gr/sdcf) at the inlet to RTO units on direct wood-fired OSB dryers employing ceramic saddles as heat transfer media. The particulate concentration data are for the filterable particulate only. Dryers processing aspen only, a mix of aspen and pine, and southern yellow pine only are all represented in this curve.

The two RTO units that were decommissioned after 5.25 years of operation (noted as data points 1 and 2) showed no alkaline attack on the media at that time. Prior to decommissioning, these units had never been washed out since start up and were baked out once every 35 to 40 days. There is a high efficiency wet ESP unit upstream of both RTO units.

The two RTO units noted as data points 3 and 4 have been operating for approximately 4.5 years. Neither unit has ever been washed out since commissioning, and both units are baked out approximately once every 3 months. The media, at this time, shows no sign of degradation. There is a high efficiency wet ESP followed by a secondary mist elimination drop out chamber upstream of both RTO units. The data points noted by a star symbol represent RTO units where the media has failed and was changed out with new ceramic saddles. Failure of the media was typically detected by an increase in pressure drop, increased wash out and bake out frequencies, and ultimate fusing and crumbling of the saddles. These units have a low efficiency wet ESP upstream with the exception of the data point noted as 6. This RTO unit has only primary cyclones and secondary multi-cyclones upstream.

The RTO unit noted as data point 5 indicates a media change out after 5 years of operation. It should be noted that after approximately 4 years of operation, the top two feet of media was removed due to fusing caused by alkaline attack. There is a high efficiency wet electrostatic precipitator upstream of the RTO unit.

Figure 2
RTO Media Bed Life Trends



Discussion

A number of pertinent points must be considered when evaluating the trends shown in Figure 2. Firstly, the test data as shown represents only one point in time. It must be asked whether the inlet condition reported for one test represents actual operating conditions over the course of years. Variability in performance of an upstream particulate collection device (i.e., a wet ESP) could seriously affect the actual inlet particulate concentration seen by the RTO over time.

Another point is that different wood species grown in different locations can have a radically different content of alkaline earth metals. Even within a particular species, the location where the trees are grown can have a significant effect on the alkaline content. This will in turn have a large effect on the concentration of these oxides entering the pollution control equipment.

The last point is the RTO design. The size of the heat recovery chamber relative to the volume of exhaust gas treated can significantly affect the length of time an RTO will operate before experiencing plugging and media degradation problems. Some RTO units are designed with very large cross sectional area for the heat recovery beds for a given gas flow. This results in a low face velocity. These units will operate longer than a unit with smaller heat recovery beds before problems begin to appear.

In short, there are other variables that can affect the location of the data points reported in Figure 2 that have not been correlated. However, the data shown do present a trend with clear implications.

Conclusions

An RTO unit on a direct wood-fired OSB dryer with no additional particulate control will see inlet particulate concentrations in the range of 0.08 to 0.25 gr/sdcf (183 to 571 mg/Nm3). The life span of the media bed is likely to be less than 1 year and perhaps as short as 6 months.

At the other end of the spectrum, an RTO unit with an inlet concentration of particulate in the range of 0.005 gr/sdcf (11.5 mg/Nm3) can expect an operating life for the heat exchange media of 5 years or more. The condition of the media in those units still operating at 5 years indicates that there are multiple years of service remaining.

References

1. CFR Title 40, Part 60, Appendix A (revised July 1, 1997)