GENERAL COMPARISON OF A THERMAL OXIDIZER (TO) WITH AN OXIDATION CATALYST (OC)

INDUSTRY EXPERIENCE: A TO and an OC are tried-and-true technologies that are used extensively in industrial applications.

DESTRUCTION EFFICIENCY: A TO and an OC can combust (destroy) torrefaction gases (VOCs and CO) at an equally high rate of efficiency (up to 99+%).

OPERATING EFFICIENCY: With a TO, to assure complete combustion, approximately 10% excess combustion air must be used to result in an exhaust gas with an oxygen concentration level of at least 2% (with operating results often higher). With an OC, excess combustion air can be tightly controlled to result in an exhaust gas with an oxygen concentration level of only a few hundred ppm. Since combustion air must be heated in the combustion process, the amount of excess combustion air required by a TO significantly reduces its efficiency as compared to an OC. In addition, a TO must operate at significantly higher temperatures (1,600° F) for complete combustion to occur. An OC can achieve complete combustion at around 950° F. This lower combustion temperature results in significant energy savings.

PROCESS HEAT: The combustion of torrefaction gases in a TO and an OC produces energy (heat) that can be used in the torrefaction process. Because an OC is more efficient than a TO, for a given amount of torrefaction gases, an OC will produce more usable process heat than a TO.

EXHAUST GASES: Exhaust gases from a TO contain, at a minimum, 2% oxygen (with operating results often higher). Exhaust gases from an OC can be controlled to contain an oxygen level as low as several hundred ppm. As a result of this negligible oxygen level, exhaust gases from an OC can be used as a free inert purge/sweep gas throughout the torrefaction process and as a cooling medium in the cooler.

SAFETY: Due to the level of oxygen in the exhaust gases from a TO, those gases cannot be used in direct contact with the biomass in a torrefaction reactor. Exhaust gases from an OC, however, are essentially inert and can be used in direct contact with the biomass in a torrefaction reactor.

> **Direct Contact Reactor**: Using inert exhaust gases from an OC as the heat source, as compared to using a VOC-laden torrefaction gas recycle loop (the current standard), drastically reduces the concentration level of VOCs in the reactor (and the system as a whole) resulting in a much safer process, both from the standpoint of fires/explosions and employee health concerns (and resulting in a significantly reduced likelihood of condensed VOCs causing operational problems or forming on the final product).
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> **Indirect Contact Reactor**: Using inert exhaust gases from an OC as a sweep gas in the reactor (or, if desired, as a sweep gas and source of part of the process heat) drastically reduces the concentration level of VOCs in the reactor (and the system as a whole) resulting in a much safer process, both from the standpoint of fires/explosions and employee health concerns (and resulting in a significantly reduced likelihood that condensed VOCs will cause operational problems or form on the final product).

COST: Although a detailed analysis has not been prepared, initial indications are that the costs of installing, operating and maintaining an OC are not in excess of the costs of installing, operating and maintaining a TO.