

**USING FLAME QUENCHING TO REDUCE
NOX EMISSIONS AND
HIGH TEMPERATURE CORROSION**

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ABSTRACT

The most complex process in the combustion field is the waste-to-energy process. This is due to heterogeneous nature of the feeds, whose BTU value can vary substantially, in spite of the efforts expended by designers and operators to effectively mix the feed.

As a result, first pass temperatures (at some locations) can reach 1,800° to 1,900°F, promoting high temperature corrosion and erosion.

This paper will discuss flame quenching by means of injecting fine water droplets into the center of the flame (adiabatic region). This practice has the potential to reduce and control the furnace temperature (ten (10) gallons of water takes away 170,000 BTU). The potential benefits of flame quenching to be discussed will include the following:

- Increasing combustion gas turbulence by a sudden increase in water volume of 1,670 times (water to steam);
- Reductions in CO and VOCs due to better combustion gases mixing;
- Reductions in combustion velocities and tube erosion rate;
- Reductions in NO_x by lowering flame temperature; and
- The generation of new revenues by utilizing moderately contaminated wastewater or groundwater contaminated from industrial sites.

Potential disadvantages of flame quenching to be discussed will include the following:

- Possible loss of revenue due to the loss of BTUs; and
- Development of slag due to large water droplet sizes or high water velocities.

INTRODUCTION

Tipping fees and electricity sales are the basis for paying the operating expenses for a waste-to-energy facility. However, tipping fees are often limited by how much surrounding landfills charge, and electricity production (MW), hence electricity revenues are regulated by Federal regulations governing co-generation facilities. In addition, waste-to-energy facilities often receive low revenues for the electric energy (MW) which are sold.

This tight revenue environment may force facilities to lose money, while others may run their units close to or above their design BTU load in order to meet O&M expenses and debt service obligations. Operations in excess of design loading, in combination with having a heterogeneous waste supply (variation in BTU), causes high temperatures at the first pass (top of the first pass reaching above 1,800°F), promotes high tube failure due to boiler corrosion and erosion and increases generation of high thermal NO_x.

The term NO_x commonly refer to all of the oxides of nitrogen. However, its composition within the stack is considered to be approximately ninety-three percent (93%) nitric oxide (NO) and five percent (5%) nitrogen dioxide (NO₂). Nitric oxide is a colorless, odorless gas formed in mainly two ways: 1) when nitrogen is present in the fuel (“fuel-bound NO_x”) which is generated directly from combustion; 2) at high temperature, reaction of nitrogen and oxygen produces NO_x called thermal NO_x. Thermal NO_x generation is exponentially dependent on temperature and also a function of oxygen concentration and retention time.

POTENTIAL BENEFITS FROM FLAME QUENCHING

Various techniques have been tried to reduce thermal NO_x and high temperatures/BTUs in the first pass, including addition of water to the feeds (waste). This technique reduces BTU, but also increases required retention time for complete combustion in the furnace, thereby increasing unburned material and reducing flame stability. Other techniques that have been used in utility boilers for NO_x reduction include load reduction, excess air reduction, stage firing, chemical injection (urea or ammonia) and steam injection.

Water injection (flame quenching) is the oldest technique to control the flame. Firefighters inject water at the base of flame in order to cool the material, restrict generation of volatile gas and block oxygen uptake. In our case, we do not want to contain the fire. Therefore, fine water droplets are injected into the center of the flame