Ozone

Mastering the Fundamentals of Ozone: *mass transfer*

In the March 2008 issue of Water Quality Products*, the IOA column discussed mastering the fundamentals of ozone and reviewed the four basic elements required to form fully functional ozone systems: oxygen/feed gas preparation, ozone generation, mass transfer and monitoring and control. This month, the series continues with a closer look at the third basic element: mass transfer.*

By Bob Smith McCollum

A closer look at the third basic element of ozone

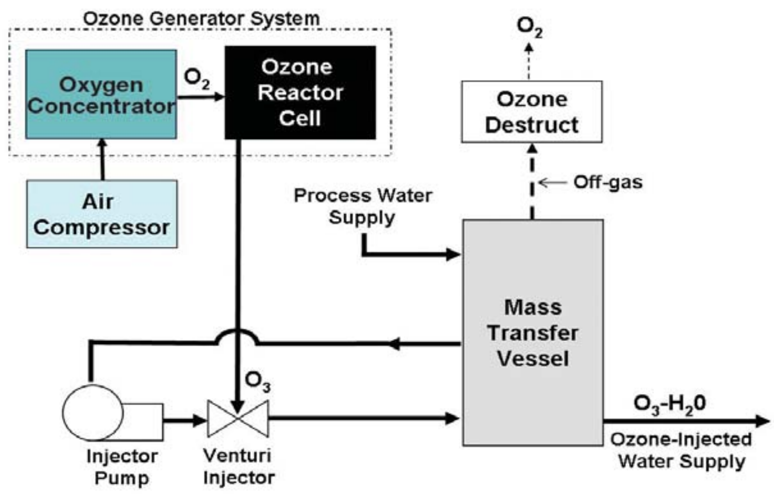
Mass transfer is the process in which ozone gas is dissolved into water. For the purposes of this discussion, we will focus on ozone systems in which the ozone gas is dissolved into water and the ozone-injected water is applied to the target application.

Ozone mass transfer may be achieved by bubbling ozone gas through a column of water via diffusion stones or by aggressively mixing the ozone with the water via an integrated mass transfer system utilizing venturi injection. When ozone was first applied to drinking water disinfection and other applications, diffusion stones were the primary method of ozone mass transfer. Today, venturi-based integrated mass transfer systems are often the method of choice for ozone mass transfer over a broad range of application types and sizes.

A basic full-flow, pressurized venturi-injection mass transfer system consists of a venturi injector, an injector pump to drive process water through the venturi and provide pressure for the downstream process, a mass transfer vessel and an ozone destruct device (Figure 1). The latter safely converts excess ozone in the off-gas back to diatomic oxygen.

Continuously operating ozone systems may utilize a small mass transfer vessel of only a few gallons. Advanced ozone systems may also include a degas separation device to thoroughly remove entrained ozone gas bubbles before delivery of ozonated water to the application use points.

Figure 1: Applications with periodic stops and starts typically include a stainless steel mass transfer vessel.



Venturi Injection

A venturi creates negative pressure or vacuum by accelerating liquid through a narrowing constriction in a pipe or tube. The pressure in the pipe at the constriction point is lower than in other portions of the pipe. The passage of a high-velocity water stream across the gas inlet port creates a partial vacuum, resulting in gas suction. Gas suction capacity is a function of the differential pressure across the injector. The higher the water velocity and the larger the pressure drop, the greater the suction capacity.

In an integrated ozone system, the injector pump drives process water through the venturi, which creates a suction that draws in the ozone gas produced by the ozone generator. The ozone gas vigorously mixes with the water flowing through the venturi, then passes downstream to the mass transfer vessel for secondary mixing and retention as needed for the specific application.

Mass Transfer Vessel

To ensure a consistent supply of ozone-injected water to the process, applications with periodic stops and starts typically include a stainless steel mass transfer vessel. The mass transfer vessel receives the ozone-injected water downstream of the venturi system to thoroughly mix the injected ozone gas and to vent undissolved gas from the vessel. The volume of the mass transfer vessel for a given application—which can range from 50 gal to hundreds and thousands of gallons—is a function of the demand and flow characteristics of the application.

Processes that operate continuously with few interruptions are best served with small mass transfer vessels of a few gallons to provide ozone and water mixing without a conventional tank. These systems are often referred to as tankless systems because they do not use a conventional large mass transfer tank.

The undissolved gas vented from the mass transfer vessel and degas separation device is discharged through an ozone destruct device, which contains a bed of heated catalyst that converts ozone gas back to diatomic oxygen and is then safely vented to the atmosphere.

Optimizing Mass Transfer

The components and operating conditions of venturi-based mass transfer systems must be optimized to meet the needs of each application. A well-designed and optimized venturi-based mass transfer system will transfer up to 98% of the ozone gas into solution.

The performance of the mass transfer system is reduced if the differential pressure does not support the gas volume to the venturi, resulting in a lower ozone dose to the water. Mass transfer is affected by the gas-to-liquid ratio and pressure at the mixing zone at the discharge end of the injector into the mass transfer vessel.

Operation of an ozone system at especially high vacuum may affect the ozone reactor cell and oxygen concentrator if the venturi suction exceeds the output of the ozone generator, limiting the efficiency of ozone generation and ultimately reducing the dissolved ozone concentration produced by the system.

To ensure safe system operation, the performance characteristics of the ozone destruct system (maximum flow rate and catalyst capacity) must match the potential output of ozone off-gas from the mass transfer vessel.

The mass transfer system is an important aspect of an integrated ozone system. A truly functional mass transfer system requires careful consideration to match the performance of the various components to work well together and meet the overall requirements of the application.

The last installment of this series will focus on ozone system monitoring and control. *wqp*

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