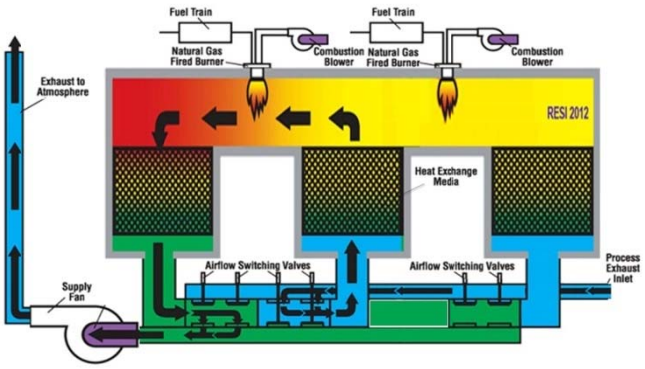
RTO TECHNOLOGIES

Regenerative thermal oxidizers (RTOs) are commonly used for the abatement of volatile organic compound (VOC) emissions from a broad spectrum of industries. An RTO is basically a thermal oxidizer that uses ceramic media as the energy swap medium, providing high heat recoveries. RESI offers many variations of this technology for industrial applications, which broadly fall under three categories: multiple-canister RTO, RTO with integrated boiler, RTO with external boiler or energy recovery unit, and PDR-RTO with integrated boiler. The PDR and PDR-RTO are the RESI patented proprietary technologies, developed for the abatement of high concentration VOCs.



The major components of an RTO system consists of heat exchange canisters, combustion chamber, and multiple valves or dampers. The RTO system consists of multiple heat recovery chambers. The air is cycled through an inlet chamber for preheating and an outlet chamber for reheating the heat exchanger bed before exiting. Before chambers switch from inlet to outlet flow, they are purged of any residual VOC laden gas. This purging ensures minimal VOC spikes and maximizes destruction efficiency.

The purpose of valves, or dampers, in an RTO system is to provide a tight shutoff of process air in order to maintain destruction and removal efficiency (DRE), and to provide a proper efficiency of thermal energy recovery (TER). Valves not only regulate the flow of VOC laden gas, but also isolate ducting and equipment for maintenance without interrupting other connected process units. Valve designs should take into account of maximum system pressure, temperature changes, and stresses imposed by the connecting ducting so as to prevent distorting and misaligning of the sealing surfaces. The sealing surfaces should be of such material and design that the valve will remain tight over a reasonable service period. Proper valve design is critical for high VOC-destruction efficiency over a long equipment life. Cycling more than 400,000 times a year, RTO valves must operate reliably and seal to less than 0.25% leakage at full system pressure.

Overview of RTO Damper Technologies

Generally, two kinds of dampers are used in RTO systems:

High-Cycle Dampers: The dampers directly connected to the RTO heat exchanger canister that direct the flow of process air into and out of the canisters are called high-cycle dampers because they need to open and close every few minutes on a continuous basis.

Low-Cycle Dampers: Most other dampers associated with a RTO system are called low-cycle, or standard duty dampers due to their lower cycling frequency. Examples of the low-cycle dampers are isolation dampers, diverter dampers, etc.

The discussion below pertains to the high-cycle valves, which are critical to the overall performance of the RTO, especially for the RTO system with high destruction efficiency. RESI utilizes butterfly dampers for small RTO unit (300 to 12,000 m3/hr/unit) and poppet dampers for industrial RTO unit with gas flow rate ranging from 6,000 m3/hr/unit to 240,000 m3/hr/unit.

Butterfly Dampers

Butterfly dampers have been applied to RTOs for over 30 years, and they basically consist of a flat plate inserted in a gas stream. It is rotated by means of a motor and linkage (often called an actuator) in order to control the gas stream flow. When the damper is in the closed position, it almost completely blocks gas flow. When it is in the fully open position, the flat plate is aligned with the direction of gas flow and therefore provides very little flow restriction.

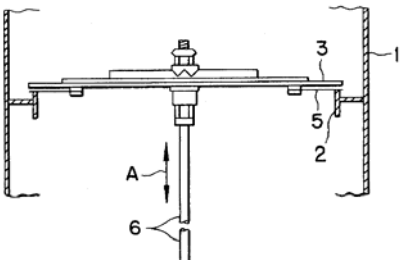
Butterfly dampers occupy less space than any other valves and have broad versatility by the virtue of their design. They are relatively tight-sealing without excessive operating torque requirements. They offer simple and reliable means for both modulating and on-off types of applications.

Butterfly dampers employ a center-mounted rotating disc or discs that typically rotate 90 degrees for opening or closing. The solid rotating disc, generally round-shaped, must resist thermal and mechanical deformations. The type and size of the damper dictates the torque requirements and, by extension, the actuation requirements (e.g., beyond a certain torque, pneumatic actuators become less desirable than hydraulic dampers due to their size).

Butterfly dampers used in the RTOs are the on-off type with two design variations: single-blade dampers, the most common type used in the industry; and double-blade dampers,

usually used in applications where very high destruction efficiencies are desired.

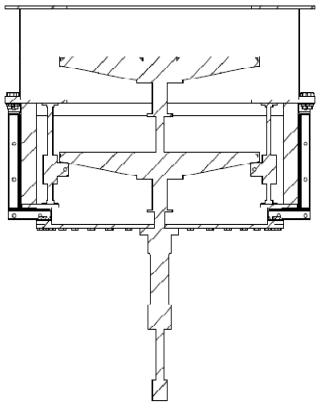
Poppet Dampers



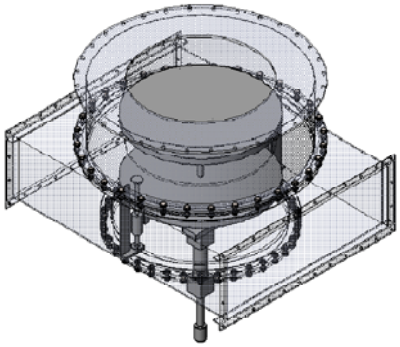
Poppet dampers have been applied to RTOs for over 15 years and consist of a flat circular plate that is raised or lowered typically by an electrical or pneumatic actuator. When the flat plate is in the closed position, it provides a gas seal by pressing against a seat, shaped like a short cylinder. Gas attempting to pass through the cylinder is blocked by the poppet plate. When the damper is open, there is a one- to two-foot gap between the flat plate and the cylinder opening. Poppet dampers are used for on-off control only; they are not appropriate for modulating applications.

Poppet dampers were initially developed for service in fabric filter systems or bag-houses, and later applied to RTOs. Fabric filter systems require two-way service with poppet either open or closed. System-outlet poppet dampers are single-disc, low-leak models. System bypass poppet dampers are leak-free, employ a double blade and seat with seal air. These valves range from 20 to 48 inches in diameter for industrial bag-houses and 48 to over 96 inches in diameter for bag-houses in power generation plant.

Poppet dampers for RTO service are more complex in that they seal multiple gas paths while diverting gas in different directions. RTO systems designed with two-way poppet dampers should have one inlet and one outlet damper providing fail-safe conditions during power outages and upset operating conditions.



Poppet dampers of this type are driven with pneumatic or hydraulic cylinder actuators for high-cycle service and low-leakage isolation. Hydraulic cylinders provide the most reliable type of drive for service where 400,000 cycles per year are expected. Poppet dampers of this type operate best when oriented vertically. They are also available with zero-leak blades and seats.



Poppet dampers with three-way and four-way configurations have also been used in RTO systems, especially for low DRE systems. A three-way poppet has one inlet and two outlets. It cycles between two seats, diverting flow through one while sealing the other and vise versa. A four-way poppet has two inlets and two outlets, and has been used in compact RTO systems

Single-Canister Rotary Valve

The single-canister rotary valve design eliminates the need for a separate inlet, outlet and valves, and replaces them with a single large valve. Rotary valve designs have been applied to RTOs for over 10 years. The sequence of the bed function as an inlet, outlet or purge is achieved by the rotation of this single valve. This valve is located below the heat recovery chambers and is either electrically or pneumatically driven. The rotation of the valve, or the distributor, continuously controls the air flow from inlet plenum to one-half of the heat exchange media through the retention chamber, through the other half of the heat exchange media, and then out through the outlet plenum.

The cylindrical canister holds multiple heat recovery chambers. The VOC laden gas is cycled through an inlet chamber for preheating and an outlet chamber for reheating the heat exchanger bed before exiting. Before chambers switch from inlet to outlet flow, they are purged of any residual unoxidized gas. This purging ensures minimal VOC spikes and maximizes destruction efficiency.

The single valve moves at several minutes per rotation and ensures a smooth transition from inlet to purge to outlet, therefore reducing upstream pressure fluctuations, which are more typical with traditional RTO designs. The single valve also requires less maintenance compared to the multiple-valve RTO system.

However, the single-canister rotary valve utilizes a machined metal-to-metal surface to achieve tight sealing. This makes it more susceptible to wear and tear. This seating arrangement also makes the single-canister RTOs more susceptible to particulate contamination resulting in lost performance over time due to inorganic particulate wearing on the machined metal-to-metal surfaces. The compact single-canister design also makes it more difficult and expensive to maintain.