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Photocatalysis: Raising the Stakes for IAQ

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ABSTRACT
The recent emergence in the HVAC industry of air treatment applications based on advanced oxidizing technologies, such as photocatalysis, presents opportunities for engineering designs that achieve improved indoor air quality, while reducing energy usage. This technology, when coupled with current *state of the art* open protocol DDC controls systems, offers building owners, operators and tenants measurable control of their environments at reduced energy costs. A case study of a gaming casino in Ecuador is presented here to demonstrate the applicability and economic feasibility of photocatalysis in building design.

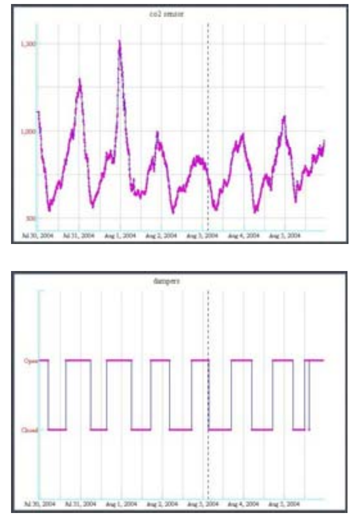
TECHNOLOGY EMERGENCE
Advanced oxidizing technologies (AOTs) are finding increased acceptance in the HVAC industry for a variety of reasons. AOTs are technologies that create aggressive oxidizing hydroxyl radicals to achieve oxidation performance increases in the range of 10^6 to 10^9 over more traditional oxidizing agents such as ozone *(EPRI, 1999)*. Photocatalysis is an AOT that uses a metal salt catalyst like titanium dioxide (TiO_2) in combination with photolysis from ultra violet (UV) light to generate these radicals. AOTs are common in medical, semiconductor and other hi-tech industries, but have only recently been considered feasible in the HVAC industry due to advances in their application to make them economically attractive for airside usage.

The recent emergence of photocatalysis in HVAC applications reveals opportunities for building owners, operators and tenants to enjoy the benefits of sound design choices in several important areas. This article focuses briefly on two of those areas: Indoor air quality (IAQ) and energy savings.

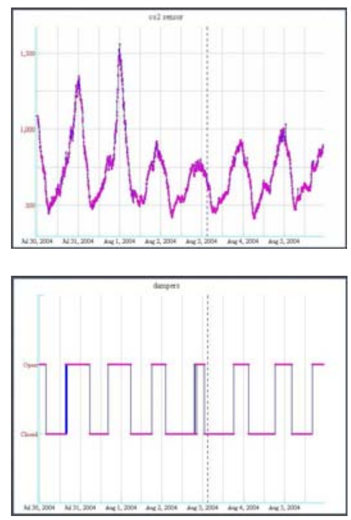
CASE AND POINT
A case study was recently performed on a gaming casino in Ecuador, an application known historically for high fresh air requirements, due to occupancy loads and airborne contaminants (tobacco smoke), and for high energy usage. Primary building cooling loads were met in various activity zones by packaged air handlers with DX cooling. Heating was not required due to warm climactic conditions and high internal heat gains. Dedicated fresh-air/exhaust-air units were employed to run continuously during occupied hours to minimize visual and olfactory detection of smoke particulates and gases and to maintain adequate oxygen levels for the gaming environment. In this instance, the fresh air intakes to the casino were hampered by the building's close proximity to ongoing construction projects and by heavy diesel smoke and other fumes produced by nearby generators and a major highway. Prior to construction completion, the fresh air units were equipped with photocatalytic inserts coupled to open-protocol DDC controls *(ASHRAE 135, 2004)*, including CO_2 sensors to monitor occupancy level *(ASHRAE 90.1, 2001)*, damper actuators to control air flow *(ASHRAE 62, 2001)*, and current transformers to monitor UV operation. After completion of project construction, monitored data were collected from the DDC system in five minute intervals via internet to create trends for performance analysis. ***Figure 1: Monitored Data*** (below) presents the monitored CO_2 levels and associated damper position data from the fresh air units during a representative one-week cycle.

EVALUATION
A computer modeling program commonly employed in the HVAC industry was used to estimate loads and perform energy and economic analyses for the facility in cases with and without the photocatalytic equipment in operation. Data collected from the building automation system via Internet was used in the computer model to establish occupancy schedules, equipment availability and other pertinent operating conditions. The resulting energy simulations were then evaluated to estimate energy savings.

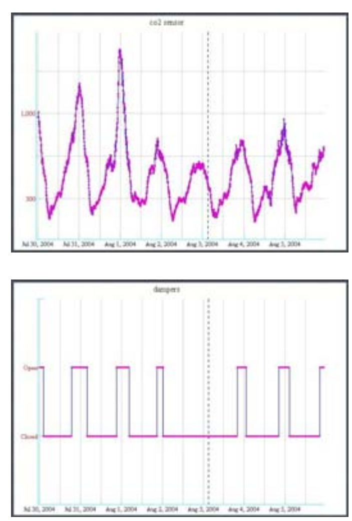
Figure 1: Monitored Data



(a) Zone 1 CO_2 Levels and Concurrent Fresh Air Damper Positions



(b) Zone 2 CO2 Levels and Concurrent Fresh Air Damper Positions



(c) Zone 3 CO2 Levels and Concurrent Fresh Air Damper Positions

Figure 2: Casino Sol Gaming Floor Showing PCO in Ceiling

RESULTS

Comparison of facility energy consumption simulations with the case of using photocatalysis under DDC control versus that of control by dilution with fresh air demonstrated an estimated savings of 10.8% in electricity consumption over a one-year period. With a utility rate of $0.072 per kwh and an installed cost of $22,000 for the photocatalytic equipment and associated DDC controls, the calculations yielded an estimated simple payback of 35 months, or 2.9 years.

Indoor air quality improvements for this case were documented from interviews conducted on-site during the facility's grand opening, rather than by instrument reading, in order to avoid the distraction of test equipment to gaming participants. Those interviewed included owners and operators of this and other casinos, as well as other parties familiar with the project. They were queried concerning perceived air quality improvements during equipment operation. Consistently, they stated surprise and satisfaction at the performance of the equipment. They noted that smoke particulates and gases were readily dissipated and odors typically associated with tobacco smoke, large crowds of people and particularly the odors present outside the facility from the nearby river, construction machinery and site clearing operations were not detectible in the gaming areas. Although not a focus of this exercise, an additional benefit derived from the reduction of fresh air usage was a decrease in relative humidity within the building from a typical 60% to approximately 40%, an amount readily noticeable to occupants.

CONCLUSIONS

Photocatalysis presents a great opportunity to address two distinctly different but important HVAC concerns, indoor air quality and energy consumption, with one elegant solution. Improvements to air quality are numerous, including control of odors and particulates such as tobacco smoke without the constant change-out or manual recharge of activated media. Benefit-to-cost ratios for this technology are high for applications within the HVAC industry, often achieving simple payback in less than one year. Measurable reductions in contaminants can be achieved at relatively low costs and documented to the extents that users determine to monitor particular constituents of concern. Photocatalytic equipment can be closely coupled to other air-handling system components or can be installed and operated in stand-alone fashion. It can be easily adapted to retrofit projects, requiring similar space usage to that of high efficiency filters. System maintenance requirements are low in both fiscal and time resources, and personnel are not required to have highly developed skills or training to maintain the equipment.

Of additional consideration, several countries have recently created incentives to encourage the use of beneficial technologies, like photocatalysis, with energy efficient design methods for projects that strive to achieve Leadership in Energy and Environmental Design (LEED) Green Building certifications.

Results from the application of emerging technologies within the HVAC industry, as presented in this and other case studies, should prompt design engineers to evaluate and to familiarize themselves with advanced oxidation technologies, particularly photocatalysis, for use in building projects where indoor air quality or energy usage are important.

ACKNOWLEDGEMENTS

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ABOUT THE AUTHOR

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