

Improving Indoor Air Quality through Sensor System Design

KEYWORDS: indoor air quality (IAQ), public health, ventilation, energy efficiency, sensor system design

HYPOTHESIS: Indoor air quality (IAQ) can be improved, thereby also improving public health, productivity and energy efficiency, by employing and optimizing IAQ sensor systems to control ventilation systems.

INTRODUCTION

Indoor contaminant concentrations can reach levels of two to five and even one hundred times higher than outdoor levels¹. Unsatisfactory IAQ is harmful to public health and the economy. An estimated \$50 to \$100 billion is spent annually on IAQ-related health care costs, while losses in productivity are estimated between \$20 and \$70 billion annually². Ventilating indoor “contaminated” air with “fresh” outdoor air is a widely used method to dilute contaminant levels. However, existing ventilation control strategies result two extreme scenarios: under-ventilation and over-ventilation³. Under-ventilation, where contaminant concentrations are not appropriately diluted, results in substandard IAQ. Over-ventilation wastes energy by conditioning extraneous outdoor air. Demand control ventilation which utilizes IAQ sensor system to control the ventilation rate has demonstrated great potential to solve the current IAQ problems. With new ventilation control mechanisms, reduction in individual building energy consumption (as little as 1%) could lead to a 10% reduction in wholesale electricity prices⁴. However, effective IAQ sensor systems design involves complex factors, such as various sensor characteristics, complicated airflow and contaminant movement, and building-specific interiors. The purpose of this research is to overcome these challenges and develop IAQ sensor system design and evaluation methodologies.

RESEARCH PLAN

The proposed research has three phases: modeling, methodology development, and validation.

The first phase, modeling, utilizes multizonal and combination multizonal – computational fluid dynamics models to predict and evaluate indoor contaminant dispersion. Since these models produce results of varying detail, this phase must first determine the appropriateness and accuracy of the chosen simulation model for any particular application.

The second phase, methodology development, uses data from phase one to develop a systematic approach for IAQ sensor system design (a design methodology). The proposed methodology will include guidelines for IAQ sensor type, characteristics, location, and quantity design. Reviewing methodologies used in sensor system design of contaminant monitoring in public water distribution systems, outdoor air pollution monitoring, and other areas will also benefit IAQ sensor systems.

The third and final phase, validation, involves implementing the proposed methodology by simulation and experimentation. Simulations with various building types can validate the ability to apply the proposed design methodology to any building type. Experimentation will validate the degree to which the proposed methodology creates an effective sensor system capable of improving IAQ and reducing energy consumption.

Results of this research include IAQ sensor system design and evaluation methodologies and a basis for the development of effective ventilation system control and optimization strategies.

Environmental engineers, epidemiologists, and health professionals all conduct indoor air quality research. I plan also to collaborate with them in a multi-disciplinary environment for this project.

INTELLECTUAL MERIT

Currently, there exists no systematic design/evaluation methodology to guide the design and application of IAQ sensor systems for ventilation control. This innovative IAQ sensor design methodology revolutionizes ventilation control and impacts other fields. For example, the design methodology can be used for homeland security to protect our nation's buildings from chemical and biological warfare attacks because an effective IAQ sensor system provides early detection and warning. Furthermore, lighting systems can utilize the design methodology to adjust lighting levels according to occupancy variations and available daylight. The research findings also benefit other sensor designs, such as those used in monitoring of public water distribution systems and outdoor air pollution levels.

BROADER IMPACTS

The proposed research will have significant societal impacts. The public will benefit from the proposed research, experiencing better IAQ and improved health and productivity. Furthermore, reduction in individual building energy consumption will lead to entire nation saving on energy. Not only does sensor system design research add to the growing wealth of knowledge of the sciences, it is beneficial to and necessary for society.

In addition the impact my research will make, I also want to make an impact as an educator. In order to be an effective one, I am taking a teaching and communications course that includes topics such as learning and teaching styles and public speaking. I also plan to obtain teaching certification, in which I will conduct classroom observations and gain teaching experience. I enjoy being a teaching assistant this term and will continue to find teaching opportunities throughout my doctoral studies.

I keep myself abreast to new teaching/mentoring resources, such as watching a recent web seminar entitled "The Mentoring Connection: Being and Finding the Perfect Protégé" offered by the Society of Women Engineers (SWE). I plan to partner with SWE and participate in their summer camps and design competitions, enabling me to impact young women and men by broadening their knowledge and opening up new opportunities for them in the field of science.

Pursuing research not only satisfies my own thirst for knowledge, it allows me to contribute new information to the field of engineering. It also allows me to further the education of our students and to help develop scientists and engineers of the future.

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