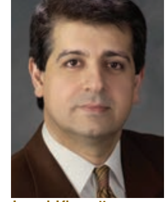

Javad Khazaii

Buildings of the Future

BY JAVAD KHAZAII, PH.D., PE, MEMBER ASHRAE

Micro-electro-mechanical systems (MEMS) were invented in the second half of the past century and since then their use has been growing rapidly. The automobile industry was an early adopter, using MEMS sensors for automobile navigation, tire pressure control and airbag deployment. As we start transitioning from today's buildings and systems to future smart buildings, design engineers will have a wide variety of MEMS applications to choose from.

Assume our building envelope and glazing systems are smart enough to adjust their own heating characteristics based on the outdoor temperature and location of the sun, to optimize the quantity and direction of heat transfer through the exterior walls, roofs and glazing systems in such a manner that is most efficient for every hour and every season throughout the year?[1] For example, one idea is for the U-values of the building envelope system (including the building glazing system) to automatically change so that, in cooling mode, the envelope can prevent heat from entering the building when the outdoor temperature is above the interior temperature setting and as the outdoor temperature drops below the interior temperature setting, the building envelope system can automatically change its U-values to allow easy transfer of the space internal heat gain to the outdoors.

Likewise, perhaps the shading coefficient of the glazing system could automatically change to protect the inside environment from the solar radiation during the cooling season, while allowing the maximum penetration of the solar radiation during the heating season. Such active envelope and glazing systems can reduce building yearly energy consumption due to an optimal amount of heat transfer throughout the year. Such advancements will generate major revisions to the current energy consumption calculation methods and tools.

A group of researchers[2] identified common HVAC equipment faults and generated a detailed fault model. They showed that these HVAC faults can affect the total HVAC energy use by as much as 22%, depending on the type and severity of fault. What would happen if buildings were equipped with fault detection and diagnosing sensors that constantly evaluate system performance, diagnose faults, and report any dysfunction, leakage or deviation from the expected construction standards anywhere in the building and its HVAC system? Such diagnosing sensors can notify maintenance staff of the most likely response required for correction. This could potentially provide for large energy savings.

What if these diagnosing sensors could evaluate the condition of the pipes and inform the building owner of possible areas for future ruptures and leaks and then provide exact locations? That would help prevent wasting treated water or other liquids or gases and therefore saving energy as well. Micro-size robots could be located strategically inside the pipes and coils so they can move locally, recognize the pipe and coil build-up and clogging locations, and target and destroy them as soon as they have been generated. This will keep the interior heat transfer surface of the pipe and coil continuously at a very good condition and, therefore, help the energy efficiency of the system. Such capabilities can change how the industry looks at building commissioning and maintenance.

Another idea is that instead of using one temperature sensor for each air-conditioning zone, use devices that monitor many smaller zones. Depending on occupancy, the sensors could be used to sense the critical heat subzones and direct the HVAC system operation in such way that maintains satisfactory conditions only in these

Javad Khazaii, Ph.D., P.E., is an associate engineer with Newcomb & Boyd Consulting Engineering Group in Atlanta.

occupied zones. Ways to do this include wearing temperature, humidity, and environmental comfort sensors sewn into our clothes, or embedded in our watches or phones, that continuously communicate with the HVAC system to direct tailored air-conditioning toward the occupants. This could also translate to higher energy savings.

What if similar opportunities are provided for pressure, and flow monitoring and measurement that multipoint monitoring can simply replace the current reliance on the single point monitoring of these parameters. We are going to have much more precise controls and much higher comfort levels due to the opportunities generated by these sensors and systems.

Another idea is to use the dissipated heat from lighting and equipment motors as a supplemental source of energy for running those motors or any other application in the building. [3]

Yashar, et al,[4] noted the small size of MEMS sensors is a significant advantage over its conventional counterparts because they allow sensors to be used in systems without being intrusive, i.e., fluid properties could be measured without significantly disturbing the fluid, and inertial properties can be measured without adding mass. Such characteristics of the MEMS sensors and systems will someday change the future smart building design, construction, maintenance, control and monitoring. HVAC designers should start thinking of ways to adapt these technologies for their needs.

References

1. Sullivan, C.C., Horwitz-Bennett, B. 2011. “Extensive R&D in the work” section of “Smart Glass, Efficient, Safe, Robust” *Building Design and Construction* June.

2. Basarkar M., Pang X., Wang L., Hong T. 2011. “Modeling and simulation of HVAC faults in EnergyPlus,” Lawrence Berkeley National Laboratory, Berkeley, Calif.

3. Varona, J., Tecpoyotl-Torres, M., Hamoui, A.A. 2007. “Modeling of MEMS Thermal Actuation with External Heat Source.” *Fourth Congress of Electronics, Robotics and Automotive Mechanics.*

4. Yashar, D., P. Domanski. 2004. “MEMS Sensors for HVAC & R, small, fast, cheap.” *ASHRAE Journal* 5. ■