Airflow and Heat Transfer

MODERN STUDIES SUGGEST that air pollution inside buildings is more of a health problem than outside air pollution. What are some reasons for this? Can you think of any solutions? Clean air is important for your quality of life, so it is important to know how to minimize pollution.

Objectives:

1. Explain convection as it relates to airflow and heat transfer.
2. Describe the effects of air movement on a building's efficiency as well as the quality of life for building occupants.

Key Terms:

air changes per hour
blower door
building envelope
chases
convection
cubic feet per minute
drag
indoor air quality
infiltration
insulators
second law of thermodynamics
stack effect
ventilation

The Movement of Air in a Building

To maintain the comfort of building occupants, airflow must be controlled and adjusted based on the heat and moisture in a building. Controlling airflow is most efficient in a building that is well sealed and well insulated. Therefore, the **building envelope**—the frame of the building, including the walls, floor, windows, doors, and roof—must be tight.

CONVECTION

Convection is the transfer of heat through movement. When outside air mixes with inside conditioned air, losses occur. This mixing can happen as a result of opening doors or windows

or because of small leaks in the building envelope. The entry of unwanted air into a building is called **infiltration**, and it affects comfort, energy costs, moisture control, and health.

The Second Law of Thermodynamics

Building operators use conditioned air to provide a comfortable environment for building inhabitants. Yet when infiltration occurs, the temperature inside the building is negatively impacted. The **second law of thermodynamics**—a rule that energy moves from hot to cold—is important in understanding how drafts negatively affect people.

The thermostat on the wall may show that a room's temperature is within a comfortable range. However, if drafts and people are present, some body heat is drawn toward the cold draft or surface. As a result, people feel cold. During the summer months, the movement of air also causes people to feel cooler. When infiltration occurs, energy costs increase because the unconditioned air that was introduced into the building through infiltration must now be treated. As a result, more heating or air conditioning will be used. Infiltration can increase energy costs by approximately 30 to 50 percent.

FIGURE 1. Drafts can make people feel cold even in a warm room.

Moisture

Unwanted moisture can be a building's greatest enemy. From the building inhabitants' standpoint, humid indoor air is uncomfortable. If the moisture from humid air enters the building envelope, a variety of far greater problems can occur. Moisture can ruin insulation; window sills and frames; drywall; and other structural elements. In addition, moisture can lead to mold in walls and ductwork, thus creating health issues.

INDOOR AIR QUALITY

Indoor air quality is the quality of the air in and around buildings. Poor indoor air quality adversely affects the health and comfort of inhabitants. It can be caused by mold, bacteria, gases, particulates, and volatile organic compounds. However, indoor air quality can be tested or measured using visual detection methods, mechanical monitors, and air samples.

Understanding Proper Ventilation

All buildings require ventilation to maintain healthy indoor air quality. **Ventilation** is the entry of desired air into a building, and it can be achieved without sacrificing overall energy efficiency. Air infiltration is measured in **air changes per hour** (ach). Well-constructed homes may have an ach of 0.25 to 0.35, while typical homes may be at 1.75 ach. But leaky homes have higher air changes per hour.

VENTILATION CONCERNS

A well-ventilated building allows for moisture and gases to escape while maintaining the highest level of conditioned air. Leaky houses result in more air changes and, therefore, more energy use. Typically, heat losses occur by means of convection through infiltration of cold air into a building. Infiltration is always accompanied by air loss (exfiltration). Although determining where air is leaving may be difficult, it is often in the upper parts of the building. For instance, every building has vertical shafts, or **chases**, that contain pipes and conduits for wiring. These can act as chimneys, conveying warm air upward in a **stack effect**. Inadequate ventilation is an energy problem. Poor ventilation in the attic causes heat to build up in the summer, resulting in higher cooling bills and the introduction of excess moisture in the home.

AIR MOVEMENT TESTS

To assess where and how much a home leaks, use a blower door test. A **blower door** is a test that includes a calibrated fan that measures the airflow rate, a door panel system, and a pressure sensing device that measures air pressure created by the fan flow. The blower door is sealed into an exterior door using the door panel system. The fan blows air out of or into the building, creating a difference in pressure between the inside and outside. The pressure difference allows the professional to highlight where air is moving between the outside and inside. This is often done using a smoke stick. After the leaks have been identified, they can be sealed. Many professionals are available to conduct blower door tests.

FIGURE 2. A smoke stick can show air movement.

AIRFLOW CAN BE IMPEDED

Air movement is measured in **cubic feet per minute** (cfm). CFM is calculated by multiplying air speed (in feet per minute) by the area (in square feet). In rooms, square footage is a

FURTHER EXPLORATION...

ONLINE CONNECTION: Predicting Thermal Comfort

Read the following article. Then summarize the key findings in non-scientific terms.

http://ceae.colorado.edu/~brandem/aren3050/docs/ThermalComfort.pdf

constant, and air speed is a variable. Faster air speed equates to more air movement. However, air movement can be affected by air quality.

FIGURE 3. Dirt and mold can impede airflow.

Drag

Drag is resistance to motion through a fluid. Yet air is considered a fluid because it moves like a fluid. Particulates and mold can inhibit air movement because of drag. This can be illustrated by the effect a dirty air filter has on efficiency. Greater air movement is required to move air through the dirty air filter. If the ability to move air faster does not exist because of the presence of particulates and/or mold, indoor air quality will be further degraded because air changes take place slower than designed. In addition, the air becomes more stagnant.

Insulators

Heat transfer operates on the principles of resistance. **Insulators** are materials that reduce the flow of heat by limiting conduction and/or convection. They are rated based on their resistance value or how much they slow down the transfer of energy. For example, dirt is a good insulator, which is not beneficial if it is on a radiator. Why? It will slow down the movement of the heat from the radiator to the cooler room air. As a result, the radiator has to work harder and/or longer to do its job.

Summary:

To maintain the comfort of building occupants, airflow must be controlled and adjusted based on the heat and moisture in a building. Controlling airflow is most efficient in a building that is well sealed and well insulated.

Building operators use conditioned air to provide a comfortable environment for building inhabitants. When infiltration occurs, the temperature inside the building is negatively impacted, and energy costs increase. However, unwanted moisture can be a building's greatest enemy. From the building inhabitants' standpoint, humid indoor air is uncomfortable.

All buildings require ventilation to maintain healthy indoor air quality. Ventilation is the entry of desired air into a building, and it can be achieved without sacrificing overall energy efficiency. A well-ventilated building allows for moisture and gases to escape, while maintaining the highest level of conditioned air. Leaky houses result in more air changes and, therefore, more energy use. Inadequate ventilation is also an energy problem. The best way to assess where and how much a home leaks, is by having a blower door test.

Checking Your Knowledge:

1. Describe the concept of convection as it relates to airflow and heat transfer.
2. Describe how proper ventilation helps to maintain a building's quality.
3. Describe how poor ventilation affects the health of building inhabitants.
4. Describe how infiltration affects comfort and energy efficiency.
5. Define and provide a formula for cubic feet per minute.

Expanding Your Knowledge:

Review the literature for five pieces of ventilation equipment. On paper, describe their similarities and their differences. Then describe the attributes you think are most important when choosing ventilation equipment.

Web Links:

Air Change Rates
http://www.engineeringtoolbox.com/air-change-rate-room-d_867.html

Blower Door Test
http://www.youtube.com/watch?v=0Vk-qk-vLb4&feature=related

Home Energy Audit
http://aahis.com/Pages/Energy.htm

Homeowner's Guide to Ventilation
http://www.nyserda.org/publications/guide.pdf