PRODUCT APPLICATION

A technical bulletin for engineers, contractors and students in the air movement and control industry

Thermally Actuated Diffusers - A Useful Device to Conserve Energy

In the HVAC industry, it is extremely important to consider energy conservation. In most commercial buildings, HVAC systems are energy hogs and they comprise a large percentage of a building's overall electric bill. On average, HVAC systems and fans comprise over 35% of a building's overall energy consumption[1]. Reducing the amount of electrical power required to condition the air in a building has far-reaching benefits, including lowering energy costs and reducing a building's carbon footprint. To accomplish this, some of the most useful devices used to conserve energy in the HVAC industry are VAV Thermally Actuated Diffusers.

What are Thermally Actuated Diffusers?

Thermally Actuated Diffusers are air diffusers that incorporate a thermal actuator that can operate the product using only a temperature difference. The diffusers are designed to function with a temperature difference of only a few degrees. These types of diffusers work well in occupied buildings and some of them allow for individual zone control. For example, in an office setting, if a localized area of the office gets too cold, then an occupant could set the thermally actuated diffuser in that zone to only open when the air reaches a specific temperature. In this example, the diffuser would restrict airflow to that zone, until the air reached a specific set point temperature, which would then cause the damper to open and allow airflow to that zone.

In contrast, traditional VAV systems utilize electronic thermostats to control the temperature for an entire zone, which allows little compensation for individual comfort and frequently leads to overheating or overcooling of occupied spaces.

Other types of thermally actuated diffusers are designed to change the airflow direction. These types of diffusers are designed to minimize the difference in temperature between the ceiling and the floor. This is accomplished by thoroughly mixing the supply airstream in the space using vertical airflow in heating mode while maintaining horizontal airflow in cooling mode. The different types of thermally actuated diffusers will be discussed in more detail in another section.

Thermally Actuated Diffuser Applications

Thermally actuated diffusers are a good solution to common air conditioning problems. One common problem is that when heating a building with tall ceilings, usually the area near the ceiling is a few degrees hotter than the floor level. Typically, the most critical area of space to air condition would be the 'occupancy zone'. This occupancy zone is where most people will be and is the area under 6 feet in height. This occupancy zone is the most critical for thermal comfort since this is where people work and reside. When the temperature near the ceiling is much higher than the temperature near the floor, this is called thermal stratification[2].

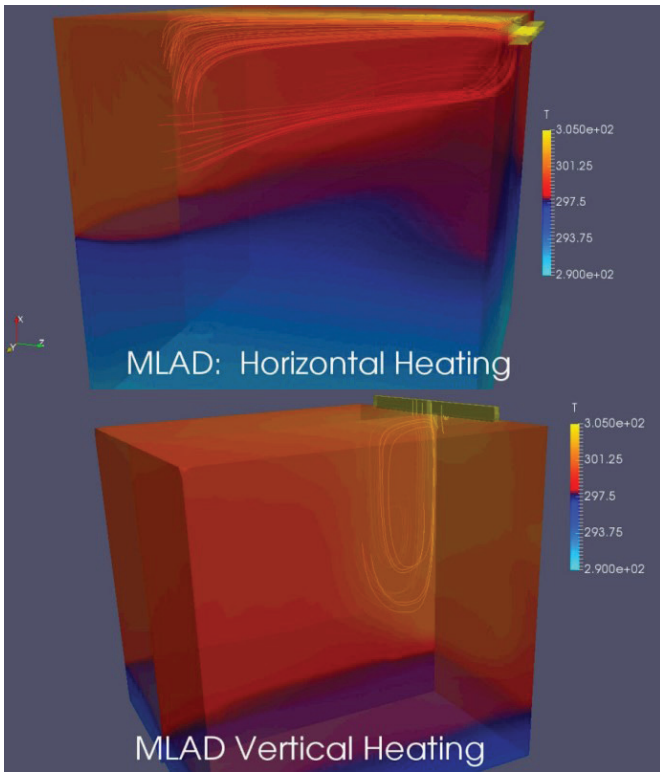


Figure 1: CFD simulations comparing vertical versus horizontal heating.

Thermally actuated diffusers can help to eliminate thermal stratification by ensuring that the airflow direction is vertical in heating mode. Typically, when a building is heated using horizontal airflow, the majority of the heated air simply rises to the ceiling before it mixes within the space. Hot air rises above colder air because of the difference in density. This buoyancy force is the same force that allows oil to float on water. When the airflow in heating mode is directed vertically, this ensures that the hot air can mix within the space before buoyancy forces cause the hot air to rise. This decreases the time needed to heat a room and therefore decreases the amount of energy needed to heat that room to the desired temperature.

Figure 1 is a comparison of two Computational Fluid Dynamics (CFD) simulations showing a comparison between vertical and horizontal heating modes. These results show that with the same amount of time, a room being heated horizontally will maintain a much higher temperature near the ceiling and exhibit more thermal stratification compared to heating the room vertically. In the case of vertical heating, the room has a more even temperature distribution and there is much less of a temperature difference between the ceiling and the floor. Using a thermally actuated diffuser that changes airflow position can ensure that no matter if the system is in heating or cooling, the airflow will be directed into the room in a way that enhances and maximizes mixing.

Another common problem with air conditioning systems is having certain zones with inadequate cooling or heating. This can lead to local discomfort of occupants and can decrease productivity in an office environment. Thermally actuated diffusers that regulate airflow are an excellent solution to this problem. For example, if an occupant in a zone is not comfortable, they can adjust the thermally actuated diffuser in their zone to have a different temperature set point. By doing this, the occupant can change the amount of cooling or heating provided to that area. They can increase or decrease the amount of conditioned air in that space, which will increase their comfort level. Typically, this is accomplished with VAV systems and electric thermostats, or other electronic control methods. However, a thermally actuated diffuser can accomplish the same benefits without using any electricity.

How do Thermally Actuated Diffusers Work?

In each type of thermally actuated diffuser, there is a set of linkages combined with a “thermal actuator”. The thermal actuator is the power behind the diffuser’s movement and is fully powered using only a temperature change. Across the industry, the most common form of thermal actuator is the Diaphragm Actuator. This type of actuator consists of a brass cylinder that is filled with a wax-type substance and has the ability to change phases from solid to liquid[3]. Upon melting, the wax gains volume which subsequently increases the pressure within the cylinder. Since the cylinder is rigid and the only movable part is the piston, the expansion of the melting wax transfers pressure forces to the piston. This pressure on the piston causes it to move outwards, and this stroke movement is what is harnessed to operate the diffuser. A cross-sectional view of the Diaphragm type Thermal Actuator is shown in Figure 2.

On average, the maximum stroke distance of this type of thermal actuator will be about 0.40 inches. Figure 3 shows a performance curve of this type of thermal actuator, plotting the stroke distance as a function that is dependent on temperature. Since most thermally actuated diffusers are designed with this performance curve in mind, the mechanisms are designed to only require a small movement. Though the distance that the piston travels might be small, the amount of force in that piston is large. By harnessing this powerful force on a set of linkages, the diffuser can regulate the amount of airflow or the airflow direction.

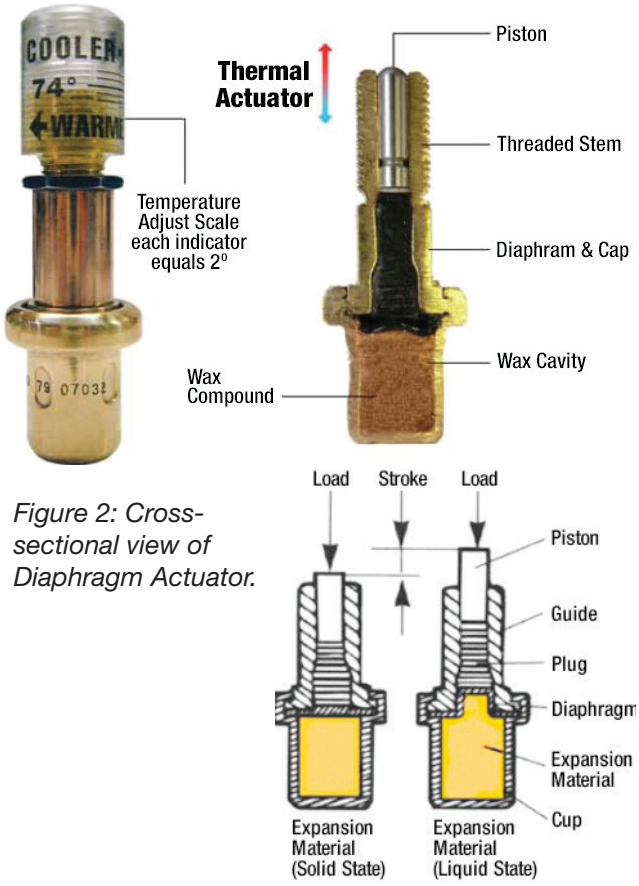
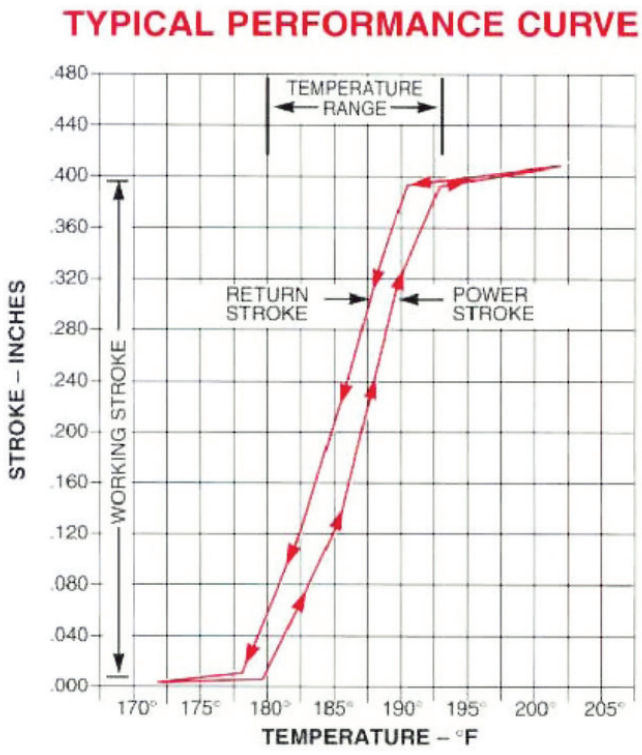


Figure 2: Cross-sectional view of Diaphragm Actuator.

Figure 3: Performance curve of a typical thermal actuator.



Another type of well-known thermal actuator is a "bimetallic coil". A bimetallic coil (Figure 4) uses two different metals attached in the shape of a strip which is then coiled. Since the two different types of metal have different coefficients of thermal expansion, each one will expand or contract a specific amount with a given temperature difference[4]. However, since the metals are attached to each other and are expanding at different rates, this creates a local stress within the coil which causes it to move. Since the thermal expansion coefficients for each material are known, the movement of the coil is easily predicted and utilized for a temperature-controlled product.

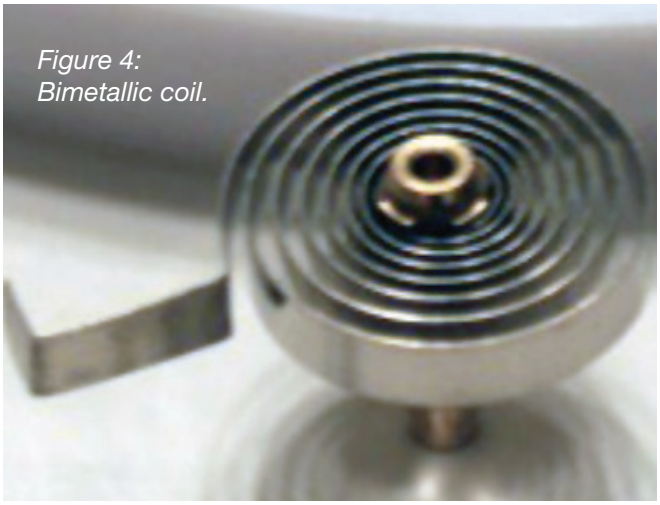


Figure 4: Bimetallic coil.

Types of Thermally Actuated Diffusers

There are a few types of thermally actuated diffusers in the market, but the main types can be broken down into just two categories. The first main type is thermally actuated diffusers that regulate the quantity of airflow. These types of products incorporate a damper and a thermally actuated mechanism that will restrict airflow that gets above or below a specific temperature. These are usually square ceiling diffusers or linear slot diffusers. A type of square ceiling diffuser in this style from Greenheck would be the model XG-MSC or the XG-MSCVH. A diagram of this type of thermally actuated diffuser is shown in Figure 5. These include a diaphragm thermal actuator, as discussed above, and uses them to regulate the airflow passing through the diffuser.

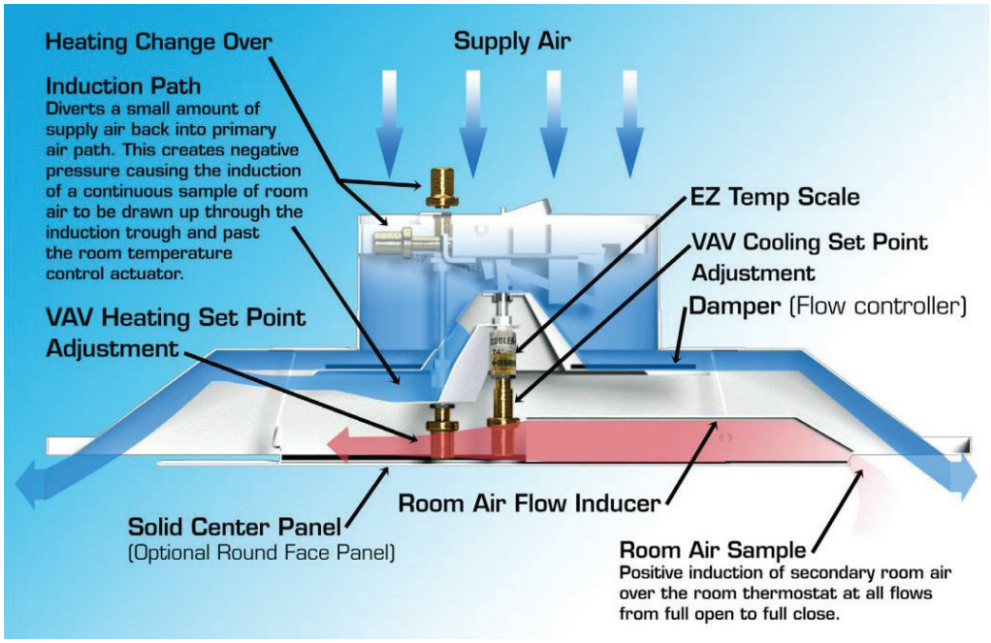


Figure 5: Thermally actuated diffuser mechanism with heat/cool changeover.

The XG-MSC and XG-MSCVH utilize a specially designed airflow sensing technology that induces room air through the diffuser to constantly sense the room temperature. This method allows for the diffuser to carefully control the amount of cooling or heating in a room and makes these products a fantastic solution for individual zone control. Greenheck also makes a thermally actuated diffuser in a linear slot configuration, and this would be the XG-MVAC or XG-MVACH. These products also use a diaphragm wax actuator and room air induction, which allow the units to control the amount of air into a room depending on the room temperature.

The second type of thermally actuated diffuser controls the direction of airflow as mentioned previously. These types of products change the direction of airflow depending on temperature. As discussed above, this is a highly effective method to reduce thermal stratification. During the heating mode, the product changes the airflow orientation to be vertical in order to enhance the mixing of the air in the room and stabilize the temperature throughout the space. In cooling mode, the product uses a horizontal airflow direction to enhance the mixing of the cool supply air into the room. Using a thermally actuated diffuser like this will greatly decrease the amount of time required to condition a room and will also save substantial amounts of energy. Greenheck offers a thermally actuated linear diffuser that changes airflow position called the Greenheck Linear Anti-Stratification Diffuser or XG-MLAD. It uses a bimetallic coil, discussed above, to change the position of the pattern deflector in order to change the airflow position from vertical to horizontal depending on temperature. See the diagram of the XG-MLAD in Figure 6.

In conclusion, thermally actuated diffusers are extremely useful in reducing energy costs for large buildings. They also help to increase the comfort of occupants by allowing individual zone control without requiring large amounts of electricity or any complicated controls. If a building is being designed, and there is concern about energy consumption, consider using a thermally actuated diffuser as part of the solution. To learn more about Greenheck thermally actuated diffusers, contact your local Greenheck representative.

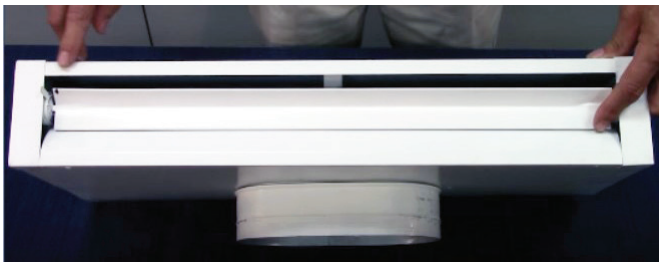
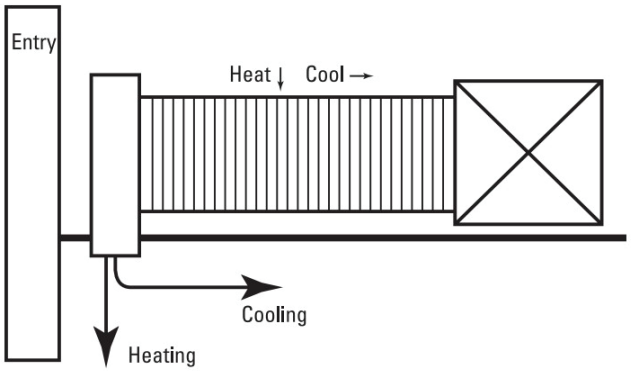


Figure 6: XG-MLAD thermal linear diffuser and diagram showing airflow direction.



References:

1. “Factsheet HVAC Energy Breakdown.” HVAC HESS, Sep. 2013, https://www.environment.gov.au/system/files/energy/files/hvac-fact-sheet-energy-breakdown.pdf

2. “What is Air Stratification and How Does It Affect Comfort and Cost?” Apollo Heating & Air Conditioning, 26 Oct. 2014, https://callapollo.com/ what-is-air-stratification-and-how-does-it-affect-comfort-and-cost/

3. “Thermal Actuators.” VERNET, http://www.caltherm.com/thermostatic-solutions/thermal-actuators.php

4. “Bimetallic Strip.” Wikipedia, Wikimedia Foundation, 25 Apr. 2019, https://en.wikipedia.org/wiki/Bimetallic_strip

P.O. Box 410 • Schofield, WI 54476
Phone: 715.359.6171 • greenheck.com