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Rooftop Ventilator Senior Design Project

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Abstract

The purpose of this research was to explore the energy savings between passive and active ventilation techniques and explore the feasability of a hybrid solar ventilator. The methodology that was employed for this research involved fluid flow analysis, thermal and heat transfer analysis and system modeling and controls. Additionally, machine design skills such as stress, failure and fatigue analysis were employed to ensure the longevity of the final design. Results can be placed into two categories. First, annual savings in terms of energy consumption for active versus passive ventilation will be displayed for various geographical areas. Second, a hybrid solar and household current rooftop ventilator design will be on display along with pertinant supporting documentation.

Disciplines

Engineering

Solar Rooftop Ventilator

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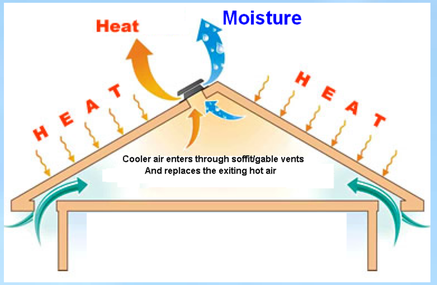
Faculty: James Ferguson Steve Hatten

Overview

Sunlight heats the rooftop via radiation. The surface temperature rises, and then heats the attic space via conduction and convection.

Heat Trapped in the attic adds to the heat load taken on by the home air conditioner.

Lowering the temperature in the attic space will reduce the load on the air conditioner.



This simple diagram shows the energy paths defined by the problem.

Rayleigh Number

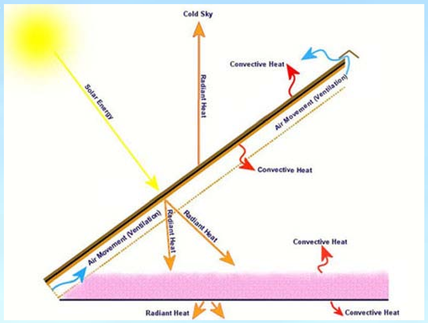
$$Ra_L = Gr_L \Pr = \frac{g\beta(T_s - T_\infty)L^3}{\upsilon\alpha}$$

Nusselt Number

$$Nu_L = \frac{hL}{k} = 0.27 Ra_L^{\frac{1}{4}}$$

Convection Coefficient

$$h = \frac{Nu_L k}{L}$$



Modeling for the different surfaces was completed using Natural Convection relationships for flow over a flat plat.
Steps:
- **Rayleigh number from Grasshoff and Prandtl numbers**
- **Nusselt number from Rayleigh number**
- **Convection Coefficient from Nusselt number relation**

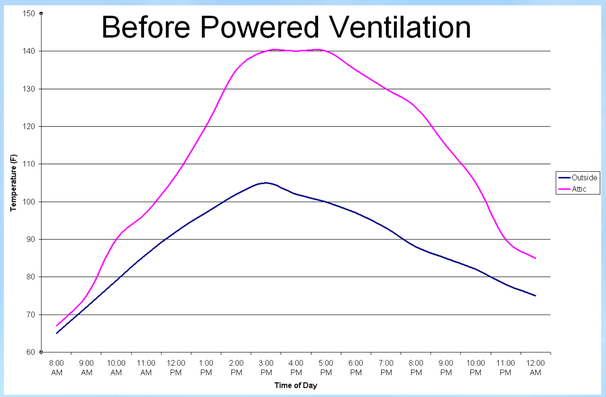
Using these correlations and a thermal resistive network the amount of heat transferred into the living space can be calculated.

Results

There is a large temperature difference between the attic air space, and the outside air on a sunny day.

The higher the temperature is in the attic space, the more heat that will transfer into the living space.

Natural convection keeps the maximum temperature below a critical point, but does not keep it very low in comparison



With powered ventilation (thermostatically controlled at 90F), the temperature difference is able to be lowered dramatically.

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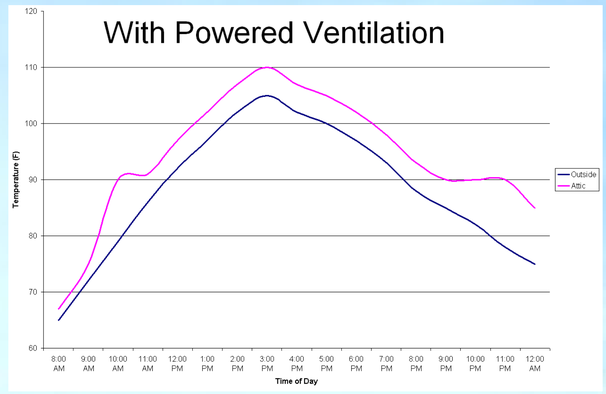

Conclusion

Curling shingles, and attic mold are results of poorly ventilated attic spaces.

Powered ventilation is a great way to ensure proper attic ventilation. It will decrease attic temperature, and moisture, and thus increase the life of material in the attic/roof space. However, the most cost effective way to decrease the load on household air conditioning is proper insulation. Powered ventilation is still beneficial, as long as the energy cost is low.

Though solar powered ventilators have a much larger initial cost (off the shelf), they will save money immediately, due to ease of installation (self contained), as well as over time due to the energy (solar) being "free".

Proper attic Insulation - R-38 about 15" of insulation.

There are two basic ways to ventilate an attic.

Either passively via natural convection, or powered ventilation, both utilizing various vents around the perimeter of the attic.

Passive vs. Powered

Passive

Pros:
- No electrical power used
- No wiring need

Cons:
- Inconsistent
- Will ventilate when not needed
- Need large amount of roof penatrations

Powered

Pros:
- Can be controlled via thermostat
- More reliable
- Constant output
- Thus, ensuring proper ventilation

Cons:
- Needs electrical wiring in the attic
- Takes electrical power ($$)

Two of the ways considered to power the ventilator are via Solar and Household Current.

There are Pros and Cons of each

Solar vs. Household Current

Solar

Pros:
- FREE
- Self contained
- Low voltage (safe)

Cons:
- Require light source
- Inefficient
- Relative High Cost
- Low voltage (eff.)

Household Current

Pros:
- Constant Source
- More efficient
- Reliable

Cons:
- Uses household electricity
- Electrician Needed

Here is an Arctic Breeze ™ solar powered attic ventilator. This will be very close to the design of our unit due to its compactness, ease of installation, and that FAMCO already produces the unit, minus the fan and panel.

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