Study of Heat Loss: Commercial and Residential

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Abstract

There is much savings involved in the prevention of heat loss. Many structures exhibit such loss. Much can be done to improve or minimize the heat loss in a structure. These include interior and exterior modifications. It has been shown that heat can move by means of convection, conduction, and radiation. Problems with heat loss can be due to moisture, and poor construction techniques. There is a beneficial cost savings involved in the prevention of heat loss. Prevention techniques include insulation, caulking, weather stripping, and double pane windows. There are tables available for one to reference and calculate the return on their investment or "payback tim"

1 Overview

In recent years the subject of heat loss has been a growing concern among the masses. People are always looking for ways to "beat" the power companies financially and save money in the process by trying to keep gas and electric bills low. This is not always an easy task for structures, both domestic and commercial, are often designed poorly and exhibit a great deal of heat loss.

This paper will address the topic of heat loss by identifying major causes of heat loss in domestic and commercial environments. It will also look at ways to identify and prevent heat loss. Finally, this paper will address how beneficial (financial, economical) the prevention of heat loss can be.

One of the key driving motivations for the writing of this paper was the many evenings spent at my desk doing work next to a window that exhibited a tremendous amount of heat loss. In the winter of 94/95, I once put a thermometer on my desk below this window and was in awe (as well as being frigid!) at the temperature reading it produced, 40 deg F. The conditions outside were windy with the temperature around 12 deg F. From this I thought it might be beneficial to read and research the topic of heat loss / space heating and the methods used to minimize such losses.

2 Introduction

It may be useful to first start off by explaining the word heat and its meaning. Heat, for all practical purposes, is a form of energy. Like other forms of energy, *e.g.*, mechanical, electrical, chemical, etc., heat energy obeys two laws of thermodynamics. The first law, entitled the First Law of Thermodynamics, simply states that energy is a conserved quantity. It may be transformed from one form to another, but it can neither be created nor destroyed. Another important physical law is the Second Law of Thermodynamics. Here, heat will always flow from a given region to another region of lower temperature. So for example, when one wants to heat an enclosure some of the heat will flow out toward colder regions. Another aspect is that when energy is transformed from one form to another, (when heat is involved), it changes in such a way that the amount of work that can be obtained from it decreases [6]. An example here would be the burning of gasoline in an automobile. Some of the energy is turned into heat and this energy is lost, meaning it cannot be used to obtain work from it.

Adding this heat to a body will increase its temperature. So temperature can be thought of as a measure of the intensity of heat content. In the English system a common unit of energy is the British thermal unit or Btu. It is defined as the quantity of heat required to raise the temperature of one pound of water one degree Fahrenheit at or near 32 deg F [11].

The flow of heat through a surface or object depends on the temperature on each side of the surface. No material can completely stop this transfer of energy which may be by one or several heat loss mechanisms [11]. In essence, the flow of heat depends on the temperature difference. Also, the amount of heat which passes through a given surface should be proportional to the time of flow. The product of the temperature difference and time, in units of "degree-days," can be used to measure the amount of heat that passes through a surface. The basic temperature for the degree day is calculated from 65 deg F. "Degree days" is a measurement of the *extent* of cold temperature. The degree-days are often calculated for particular regions of the country (see Appendix 2). This figure is used to size the heating system required [2].

3 How is Heat Lost

Heat can be lost in a variety of ways. Some of these are heat loss by infiltration, losses by conduction through floors, ceilings, single glass windows, double glass or plastic covered windows, doors, and heat losses by conduction through walls. There are mainly three such methods in which heat moves. These are *convection, conduction and radiation.* This loss by means of conduction can be thought of as the transfer of heat energy through or within a solid. The rate of heat transfer is a function of the density of the solid and its molecular makeup [7]. This transfer rate varies from material to material. Heat can also be transferred through a fluid. This is called convection. *Infiltration* heat loss, on the other hand, can be thought of in the following way. Air which has been heated to room temperature escapes through a crack or open door. This air is replaced by air at an outside temperature which must be heated to room temperature. The effect is the same as if the heat flowed from the room through a wall. By knowing the material make up of walls, ceilings or other surfaces (for lack of a better word), one can calculate meaningful values of heat loss through the mechanisms mentioned above.

The R-value is often used as a convenient measure of insulating ability.

The higher the R-value, the greater the ability to retard heat flow.

4 The Moisture Problem

The presence of moisture in the exterior walls of a building reduces the effectiveness of insulation and may in fact deteriorate the framing and structural materials as well as contribute to unsightly stains and affect the building's appearance [6]. Vapor transmission through a material is similar to that for heat conduction through a surface which was described earlier. It is dependent on time, surface area, vapor pressures on both sides of the surface, thickness, and permeability, which is a measure of a material's ability to transmit moisture. One type of problem is when condensation forms on walls, floors or ceiling sections of a building. Here the insulation value (R) is reduced because air pockets in the insulation material are now filled with water. It is this water that creates the problem. That is because water is a good conductor or poor insulator. This may also lead to structural damage. The trick is to prevent vapor from penetrating the exterior shell of the building. A layer of polyethylene film, which is a poor conductor, is an effective barrier against this moisture problem. It should also be noted that a building can be made too air tight. Meaning that there can be poor circulation thus resulting in moisture problems. A building or home should have at least one air change per hour. If this is not the case then ventilation concerns need to be addressed.

5 Identification and Prevention of Heat Loss

One way in which to evaluate a structure's possible heat loss is to employ energy audits. Audits are classified into three types, type A, B, and C. These classes are dependent on the depth or intensity of the audit. The residential sector concerns itself with program A audits and class B audits. Program audits are conducted by qualified auditors while B audits are normally mail in type audits. The nature of these audits may be on site audits where one identifies locations in which energy is consumed or lost. There are a variety of methods used in determining these locations of heat loss. One such method is the use of infrared techniques. Here one can use thermal infrared aerial surface images and images collected from ground based systems to evaluate structural heat loss (for further reading see NYSERDA final report [10]). Other factors include physical size, structure, and composition of the building. Another type of audit is called a billing audit. Here, the audit is based on consumption habits and trends.

A key factor in the prevention of heat loss is the use of proper insulation materials accompanied by correct installation techniques. Thermal insulation is any material, or combination of materials, which provides resistance to the flow of heat energy [11]. Insulation can come in a variety of shapes and material make-ups. It may come as sheets, rolls, or blankets. It may also be of a loose type that is poured or blown in. The loose type is usually made up of glass fiber, rock wool or cellulose where the roll or blanket type may be made of glass fiber or rock wool. These materials vary in their advantages and disadvantages.

Heat loss may also be reduced by caulking. Caulking fills in cracks where window frames or door frames meet walls. Caulking comes in a variety of types and can last from two to twelve years if applied correctly. Weather stripping is yet another material used in the prevention of structural heat loss. Weather stripping should be applied to sliding windows, awning windows, jalousie windows and doors. The use of storm windows can also help significantly in the prevention of heat loss. Double paned windows will have an insulating value of up to R-1.8. Compared to a wall's insulating value of R-12 to R-40, windows can represent a significant heat loss [1]. These window should be fully weather stripped and/or caulked.

It may be beyond the scope of this paper to describe the actual steps or procedures involved in installing insulation but some key points should be mentioned. When installing blanket type insulation in areas above ceilings the vapor layer should always be closest to the ceiling itself. In walls, there should be a vapor layer on the inside wall to help reduce moisture penetration.

There are other factors as well, involved in the equation for over all heat loss. One needs to consider geographic location and climate of the area of interest, taking into account degree days. Also, the sun path, wind direction, vegetation, soil, frost lines, and placement of other building must be taken into consideration [2].

6 Word about Wood

Wood can also be thought of as an additional source of thermal energy. Many people have implemented wood burning as an addition to the conventional oil and gas heating systems. Much of the energy in wood is bound up in the gases in the wood. To burn these gases the wood needs to burn at a temperature over 900 deg F. It should also be noted that *outside* combustion air should only be allowed to enter the fire. This will improve the efficiency somewhat, though the use of wood stoves is still too inefficient to be considered a viable space heating system.

7 Costs and Savings

All the above mentioned improvements involve some type of capital to implement. So it is here that we will discuss the so call "return" on one's investment. This is often called payback time. An important factor here is human comfort. This is most difficult to define and varies amongst individuals. Still another factor is the value of the dollar. Included in the "investment" are factors such as initial costs, installation costs, and maintenance costs. The savings can be with respect to "the existing system to be replaced, supplemented, or improved" [6]. The payback time is found by dividing initial costs by first year savings. For example say a thermal correction cost $900 in the natural gas-heated home. With an annual savings potential of $663, we would get our invested thermal correction dollar back in about 1.35 heating seasons [7]. The payback period may vary with time. This can be due to price fluctuations in fuels, inflation or the value of the dollar. The dollar today may have a different value, or buying power, than the dollar of the future. Tables do exist and calculations can be made for determining present values and cost effectiveness. A short listing can be found in Appendix 1.

8 Concluding Remarks

Overall, much can be done to improve or minimize the heat loss in a structure. These include interior and exterior modifications. It seems that from most perspectives the exterior approach is the preferred option. We have shown how heat moves, how it is lost through a structure and ways in which to minimize the loss of heat. We have also showed the potential cost effectiveness associated with the prevention of heat loss.

This paper has been especially interesting in that it seems to have a large portion of practicality associated with it. Meaning that, the initial thrust for the paper was to gain a better understanding about heat energy losses. With the work involved in researching the topic much insight has been gained about the topic of heat loss and practical means in which to prevent it and be cost effective. This means, no more breezy windows that freeze my body while working at my desk.

This paper was written with future reference in mind. I hope to, someday, look back and reference the paper while extracting useful information from it.

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Subsequent studies investigating the accompanied by instructions for customizing similar data for specific effects of 1981 to 1985 RTF data indicated results generally less application; a microcomputer database was also provided to facilitate conservative than those computed with the 1972 data. More recent such calculations. Certain limitations resulting from normalization of research, however, suggests otherwise (McQuiston 1992), and the data remain, for which anticipated error ranges are listed to aid in revised values for 1993, including the new SCLs, are currently con- evaluating results. Heat loss through windows can be reduced by using double glazing. These special windows have air or a vacuum between two panes of glass. If the double glazing has a vacuum there will be no conduction or convection. If the double glazing is made with air between the glass then convection is minimised because there is little room for the air to move. Air is a poor conductor so there will be very little heat loss by conduction. Heat loss through walls can be reduced using cavity wall insulation. This involves blowing insulating material into the gap between the brick and the inside wall. Insulati Heat losses from foundations contribute significantly to residential heating requirements. For example, in a sampling of 33 energy-efficient houses (ongoing study; see, for example Gusdorf and Hamlin 1995) it was found that 16GJ to 52GJ were lost annually through foundations. This represents (on average) 24% of the total heating load for these houses. Foundation losses can be even higher with conventional (non energy-efficient) construction.Â A regression-based algorithm has been developed for estimating residential-foundation heat losses. The algorithm, known as BASESIMP, can accurately. model most foundation configurations of interest.