#2541 HAC March 1987 AIVC 2057

2541

Heat balance studies: Part 1

In this, the first of a four-part series, R.M.E. Diamant describes a new series of computer programs that bring together the various heat losses and gains to be calculated in any type of building ■

The computer programs on energy management in buildings that I began to write three years ago suffered from the weakness that heat losses and gains through various walls, windows and roof sections had to be calculated separately, and then co-ordinated afterwards.

This has now been overcome and the program package Heatbal co-ordinates all heat losses and gains in any kind of building, situated anywhere, and used in a multiplicity of ways.

The package deals with dozens of different parameters, such as the exact construction details of every roof and wall interface, their sizes and geographical location, down to the degree of ventilation practised and how long and by whom it is occupied. The output data deal with all kinds of heat losses and gains, and specify finally the dimensions of heaters needed to maintain a specified ambient temperature within.

The advantage of using such a computer program package is that one can determine the effect of using various methods of design and construction on energy loads, simply by playing about with the computer. One need not lay a single brick or position even a foot of pipework. Before the beginning of the computer age such studies could only be done the 'hard way', by carrying out an expensive pilot study.

The trouble with energy calculations is not only that they are complex but also that they involve a massive number of variables. Most heating and ventilating installers, designers and others concerned with buildings are therefore prepared to make short-cuts when carrying out their calculations. This inevitably leads to trouble.

I decided to write my program package Heatbal in several sections, which are connected together (chained in computer jargon) so that one goes automatically from one program to the next. All intermediate results are stored in so-called files. In actual fact, this way of working has certain advantages in that one can divide the problem up into convenient sections, and can repeat certain calculations, without always having to restart from the beginning.

Because all calculations of this type have in the past been done by hand, which certainly limits the scope, I found it was necessary to consult work done by numerous *different* authorities when writing this package.

The Building Research Establishment at Garston issues excellent guidelines, as do the British Standards Institution, the Institution of Heating and Ventilating Engineers and the Heating and Ventilating Contractors Association. Wherever possible I have used their findings for my programs.

■ Actual windspeeds

The material is, unfortunately, not quite as comprehensive as I would like. There are many aspects that I consider important which are not fully covered. For example, the sources quoted subdivide buildings into sheltered, exposed and very exposed, which I consider too vague. I prefer to use actual wind speeds. Other important aspects are not dealt with at all.

I have found some of the mathematics contained in the German DIN 4701 and DIN 4108 most useful. The Swedish BABS specifications and recent published work by numerous scientists in the field have been used to amplify the basic guidelines published by the British Building Research Establishment, and Codes of Practice issued by various British authorities.

I would claim that this package is the easiest to use of any of the heat loss packages around today, as no computer jargon is employed in the very simple questions asked, or in the replies which are given by the computer.

The program series was originally written on a BBC(B) computer and translated for the IBM PC. This means that the package can be used on all the modern computers which are compatible with the IBM (which will soon include nearly every computer on the market). It can also be used with Apple, Commodore and Amstrad computers. Both the Metric (SI) units and Imperial (American) units can be used. At the beginning, the user simply types in 'M' for metric or 'E' for English units.

The package is subdivided into an introduction and six distinct program sections. At the end of each section the user is given the opportunity to restart the appropriate section without losing previous data. If everything is OK, the next section is loaded automatically. After one has gone through the entire package of programs one can start at any position of the program provided one does not wish to alter earlier work. For example, one can start in section HB6 if one merely desires to alter the design of the heaters.

Program HB1, the first section of the package, deals with the various roof and wall interfaces.

The techniques are the same for roofs and walls. The user is asked to specify from a menu the nature of the materials of construction going from the outside inwards, as well as their thicknesses. In the case of ceramic materials (brickwork, concrete, breezeblock and the like), the k-value is worked out from density and moisture content by regression analysis. A k-value for the insulation materials is suggested by the computer which the user can override if so desired, by substituting a new value. The computer evaluates the thermal resistance of each constructional layer as well as the external and internal boundary layer resistances and the thermal resistance of any air cavity between solid layers.

The printout gives full details of each layer and of the final U-value which has been calculated by the computer. It then asks:

1. Does the wall face unheated premises (garage etc)?
2. Any windows? If so, give height and width (including roof lights)
3. Length and width (height) of roof or wall interface.
4. Any external doors to walls?
5. Compass direction into which wall section faces

U-values are determined by standard methods developed by the BRE using the method of summation of thermal resistances. The external laminar resistance comprises the sum of the radiation heat resistance, which is itself evaluated from the Stefan

Boltzman law, and the convection heat resistance, which is windspeed-related and is evaluated by application of the Langmuir equation.

The Stefan Boltzman equation is the following:

$$Qr = 5.673 \times 10e\,((Ts)^4 - (To)^4)\ W/m^2$$

while the Langmuir equation for convection heat transfer is generally quoted as:

$$Qc = 1.9468\ (Ts - To)^{1.25} \times ((v+0.35)/0.35)^{\frac{1}{2}}\ W/m^2$$

e is the thermal emissivity (dimensionless)
Qr is the heat flow due to radiation in watts/square metre
Qc is the heat flow due to convection in watts/square metre
Ts is the surface temperature in kelvins
Ta is the external temperature in kelvins
a is the absorptivity of the surface (dimensionless)
v is the wind velocity in m/s.

On the inside of the dwelling the Langmuir equation is also used but because the wind speed is zero it reduces to the following:

$$Qc = 1.9468\ (Ts - To)^{1.25}\ W/m^2$$

Standard BRE equations are used for the determination of the thermal resistances of air cavities between interface layers. Finally, the U-values are determined by adding the various layer resistances and taking the reciprocal. Standard BRE calculations are used to determine heat losses at interfaces which border unheated areas such as garages, porches, unheated upper floor and the like.

Calculations for roofs

Calculations for roofs are a bit more involved. With flat and hipped roofs the calculations are somewhat similar to those applicable for walls, but for pitched and monopitched roofs it is necessary to calculate heat losses through the so-called 'pikes', the section of gable walls above eaves level. Needless to say, the computer does this on its own.

Questions are asked regarding the dimensions of each of the interfaces, the presence and dimensions of doors and windows, as well as the compass direction of each of the wall interfaces.

The computer evaluates the UA factor for each of these interfaces and stores the data in a file, to be utilised in subsequent sections of the package. These, with worked examples, will be described in future articles of this series.

Further information on the 32 basic heating and ventilating programs and the Heatbal package described in this series can be obtained from: R.M.E. Diamant, 7 Goodwood Avenue, Manchester M23 9JQ tel: 061-962 2708