Heat balance studies: Part 3

Heat gains and heat losses, month by month, and the effects of building occupants, are now dealt with by R. M. E. Diamant

The industrial building used to show the package operating is in a North Western area (area 8 of the country breakdown) and the location is 80m above sea-level in a suburban area. It is a small factory (group 3), for which the computer recommends an air change rate of two an hour.

There is no reason to over-ride this figure, so it is retained. The external building surface is pale coloured. The floor has the same overall dimensions as the roof of the building, namely 40m × 15m. There is 50mm of high void insulation around the perimeter and the temperature inside the building at head height is 20°C. The floor is laid on damp clay followed by 600mm of hardcore, and a 150mm thick slab of concrete with density 2 kg/cudm and 1 per cent moisture content.

```
WINDOW AND DOOR CALCULATIONS
LATITUDE EQUALS  53.5  degrees  North
Total window area  34.56  square metres
Total door area  4  square metres
Total minimum solar radiation (January) through glazed areas equals
 74.086  kilowatt hours per day
Total average solar radiation through glazed areas over heating season
(1st October to 31st March) equals  80.222  kilowatt hours per day
```

Printout No 4: Summary of window and door calculations

Printouts 4 and 5 show results obtained.

As before, the computer now wishes to know whether it should go on. If given the answer 'yes' it moves on to section HB4 in which the user is able to specify any given month of the year to determine the heat gains and heat losses during this month.

From all the data entered in previous sections the computer is able to give the following detailed information for each specific month of the year:

- ☐ Average external temperature during a 24 hour period.
- ☐ Average temperature of the external walls which are exposed to direct solar radiation.
- ☐ Heat losses through the building fabric.
- ☐ Floor heat losses.
- ☐ Ventilation heat losses.
- ☐ Solar heat gains through walls and roof on sunny days.
- ☐ Solar heat gains through glazed areas on sunny days.

From all this the computer gives its verdict regarding total heat requirements (or air conditioning needs) on both sunny and dull days. Separate answers are also given for day-time and night-time heating needs. The user can re-specify the month of the year as often as needed so that reasonably accurate assessments are obtained of the heating needs during different seasons of the year.

This program can also be used for areas outside the temperate zones where cooling needs outweigh heating needs for several months of the year. In such a case the computer prints out the cooling requirements in terms of either watts or Btu/h as needed.

Even in countries such as the UK, cooling may be needed during the summer in buildings which are highly fenestrated or in which a lot of people gather.

Up to now we have merely considered the building shells. But there is a considerable difference in heating and cooling requirements between empty buildings and those that are occupied by people or animals.

To start off, the number of hours a day the building will be occupied needs to be established. Then an exact description of the people occupying the building is needed and their activity. Clearly, the heat output of a boat-race crew limbering up in a gymnasium is considerably higher than that of eight old ladies in armchairs watching TV in an old age pensioners' home. The thermal output of children varies enormously with age and sex.

Infants give off about 125W, girls between 9 and 12 383W and boys of the same age 418W. An average young male gives off 506W and an average young female 366W. However the heat output of a male old age pensioner is 383W and that of a female pensioner a mere 279W.

But what about farms and zoos? Animals give off a lot of heat. As the body temperature of most animals is higher than that of humans they give off more heat per unit mass than

```
VENTILATION
Airchange rate required equals  2  room volumes per hour

This is achieved by using mechanical or other ventilators to supply:
 73152  litres of fresh air per minute

The project is situated in the North western region at a height of
 80  metres above sealevel in a suburban area
The surface temperature of the floor equals:  16.76  degrees Centigrade
Thermal resistance of TOP layer of hardcore or slag equals
 4  sqm K/W
Thermal resistance of SECOND layer of concrete equals
 .1538  sqm K/W
Thermal resistance of soil equals  .85  sqm K/W

The floor area equals  600  square metres
and the perimeter is equivalent to a further  89.49  square metres
of floor area
Temperature inside building equals  20  degrees C
Temperature 100 mm above floor surface equals  17  degrees C
Floor surface temperature equals  16.76  degrees C
Effective U-value of floor equals:  .1946  W/sqm K

Heat loss through floor in JANUARY:  1302  watts
Heat loss through floor perimeter in JANUARY:  396  watts
Total floor heat loss in JANUARY:  1699  watts
Average heat loss through floor during heating season:  1025  watts
Heat loss through floor perimeter during heating season:  312  watts
Average total floor heat loss during heating season:  1338
Subsoil temperature averages  5.61  degrees C in January
and  7.98  degrees C over the heating season at a depth of
1 metre below the surface
```

Printout No 5: Ventilation and floor heat losses

```
Heating duration

The building is being heated
during the day only for 10 hours at a time
 1.5 hours being needed for heating up

SUMMARY OF BUILDING STRUCTURE HEAT LOSSES AND GAINS

Maximum heat losses (January)

Ave. external temperature 3.1 deg.C
Ave. day temperature 8.10     deg.C
Ave.night temperature -1.9 deg.C
Heat losses through roof 3179 watts
Heat losses through walls 6770 watts
Air change rate 2 per hour
Ventilation heat losses 26431 watts
Perimeter floor heat losses 396 watts
Heat losses through floor 1302 watts
Glazing heat losses: Day: 1966 watts
Total radiation heat gains through windows and
 glazed doors 9878 watts
Occupation heat gains 10854 watts

TOTAL MAXIMUM HEAT REQUIREMENTS

 141.93 kWh per day or 510.96 megajoules per day

Average heat losses over heating season
(1st October - 31st March)

Ave. external temperature 5.2 deg C
Ave. day temperature 10.2 deg C
Ave night temperature .2 deg C
Heat losses through roof 3157 watts
Heat losses through walls 6709 watts
Air change rate 2 per hour
Ventilation heat losses 23138 watts
Perimeter floor heat losses 312 watts
Heat losses through floor 1025 watts
Glazing heat losses: Day: 1948 watts
Total radiation heat gains through windows and
 glazed doors 9437 watts


AVERAGE HEAT REQUIREMENTS DURING SEASON

 96.016 kWh per day or 345.65 megajoules per day
```

Printout No 6: Building structure heating (cooling) requirements

people. By and large the heat output of animals is directly proportional to their total body mass. The standard heat output which is generally assumed is 29.12W per kg body weight. Thus a big dog

```
SUMMARY OF HEAT LOSSES AND GAINS
HEAT LOST DUE TO HOT WATER RUN-OFF  581  watts
HEAT GAIN DUE TO OCCUPANTS 525  watts
HEAT GAIN DUE TO ELECTRIC MACHINERY AND LIGHTS  3194  watts
HEAT GAIN DUE TO GAS APPLIANCES  7716  watts

TOTAL HEAT GAIN  11435  watts


NET HEAT GAIN EQUALS  10854  watts
```

Printout No 7: Heat gains and losses due to occupation

weighing, say, 50kg contributes no less than 1456W to the overall heat output inside a dwelling.

Then heat from electric and gas appliances used has to be taken into consideration. As all the energy from such appliances is going to appear eventually in the form of heat, the simplest way to find out their contribution on existing buildings is to ask questions regarding electricity meter and gas meter readings. But some of the heat will be used to heat up water which is then run into the sewers. For this reason the user is obliged to give both the quantity of the hot water run-off as well as the temperature drop. Often the user has no idea. For this reason the program suggests an average temperature drop of 60°C, which is a tolerable average for most domestic and commercial premises.

The printout gives the calculated heat losses due to hot water run-off and the heat gains due to:

☐ Occupants
☐ Electrical machinery and lights
☐ Gas appliances

Let us now return to our small factory. It will be occupied for 10 hours a day and the staff will consist of five young men and three young women in the factory itself plus two middle-aged male managers. There will be no animals present. The average monthly electric power consumption figure is estimated at 2300 units, while gas used to provide hot water etc is estimated at 200 metric therms per month. Hot water run-off at an average temperature of 60°C is 200 litres a day.

The results obtained are given in printouts No. 6 and 7. Next month, energy needs and heater dimensions. ☐

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.