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Technical Note

Summary This note arises from work to identify the effectiveness and cost of remedial treatments for condensation and mould problems in housing. Although the four factors - moisture generation, ventilation, insulation and heating - which control the likelihood of mould growths have long been established there has not been a straightforward way of showing their inter-relationship, particularly where energy costs are important. By treating the problem essentially as one of air conditioning the Note shows how the fabric heat loss of the house and the rate of moisture generation define a minimum heat requirement to limit mould growth.

Is there a minimum heating requirement for households?

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1 Introduction

Energy consumption in houses accounts for about 30 per cent of the Nation's energy use. Fuel and power for housing costs about £12 billion per year, an average of £500 per household. The range about this average is enormous, so that whilst many houses are well heated many others are not.

Poor heating can be a contributory factor to the growth of mould as a result of condensation on interior surfaces (see Fig. 1), on decorations and even on furnishings[1]. Around a quarter of a million homes are seriously affected in this way and another 2 million experience less extensive, but still considerable mould problems[2,3].

This note suggests an analytical approach which might usefully define a minimum level of heat which would significantly reduce this problem.

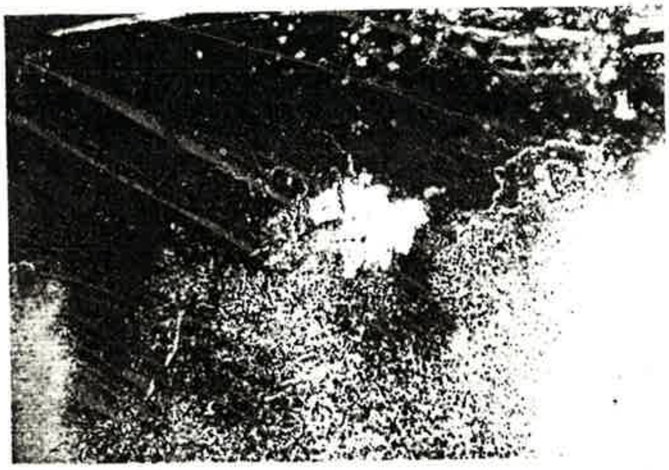

Fig. 1. Mould resulting from condensation on interior surfaces.

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2 Mould growth

Moulds require damp conditions to flourish and can be expected to appear on external walls when the relative humidity in a room is greater than 70 per cent for prolonged periods[4]. It is relative humidity that is all important in sustaining mould growth - the actual temperature of the room is immaterial. Thus the questions to be considered are: Where does the moisture come from? How is the moisture level controlled? and how can the relative humidity be kept below 70 per cent?

In housing the main sources of moisture are from the occupants breathing, cooking, bathing and laundry. A single person household might generate 0.5 to 1 kg of moisture per day. A larger family could generate 10 or even 15 kg in a day[5]. The normal mechanism of removing this moisture is by ventilation so it is most straightforward to analyse the situation with a psychrometric chart. (See Fig. 2.)

Starting with outside air, point A, then for much of the winter period this air will not only be cold, but have a high relative humidity, around 80 or 90 per cent. On coming into

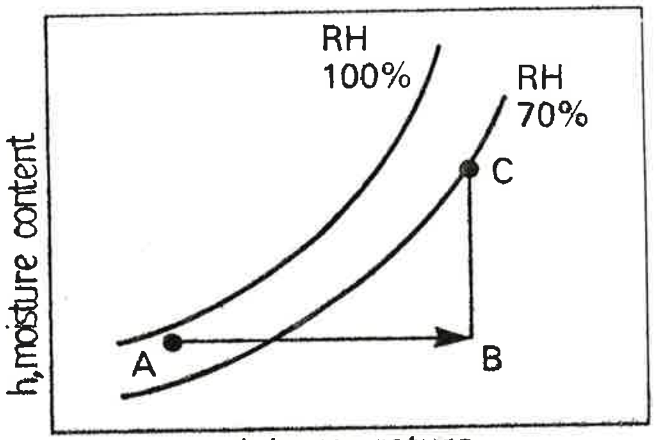

Fig. 2. Outside air (A) is heated to room temperature B and absorbs moisture (C) at the same time.

The household it warms up to temperature B and at the same Time absorbs the moisture generated internally before having the house at condition C.

If the moisture generated is G g/hour and the air needed remove this is Q m³/h then:

$\propto Q\,(g_C - g_B)$

here g is moisture content of air in g/g.

If H_a is the heat required to warm the incoming air to room mperature then:

$H_a \propto Q\,(t_B - t_A)$

$$G\,\frac{(t_B - t_A)}{(g_C - g_B)}$$

This equation is interesting in that if condition C is defined as always being on a specific relative humidity line, g 70 per cent, the ratio:

$$G\,\frac{(t_B - t_A)}{(g_C - g_B)}$$

Actually decreases as the internal temperature rises (Fig. 3). This is because the differential gradient for relative humidity lines on the psychrometric chart is always positive. The net effect is that the heat needed to warm the ventilation air to keep the relative humidity to 70 per cent actually *reduces* as the internal temperature increases. This as because the air change rate needed falls more rapidly than the temperature difference rises.

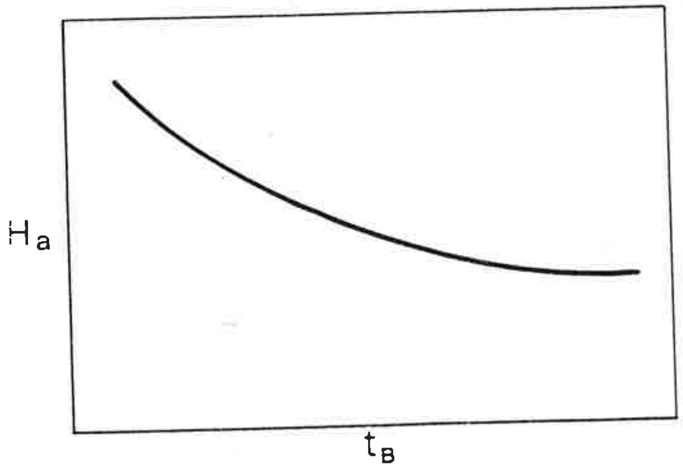

Fig. 3. For a given moisture generation rate, the heat required to keep ventilating air below 70 per cent relative humidity actually decreases as the internal temperature rises.

In contrast of course, as internal temperatures rise then fabric losses, H_f, increase. These can be expressed thus:

$H_f \propto \Sigma AU\,(t_B - t_A)$

where ΣAU is defined in the normal way. This can again be expressed graphically, see Fig. 4.

Since H_f and H_a each have the base t_B they can be added to give the total heat requirement, $H_{(a+f)}$. This summation produces a minimum, defining both the minimum energy needed and with it the associated temperature (Fig. 5).

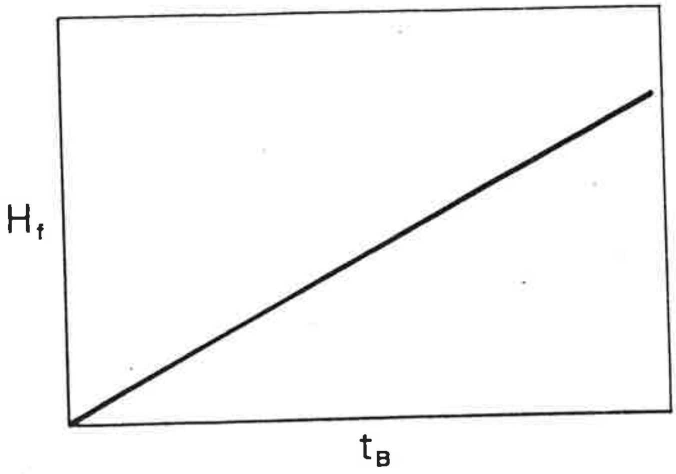

Fig. 4. The heat required to meet fabric losses is of course directly proportional to internal temperature.

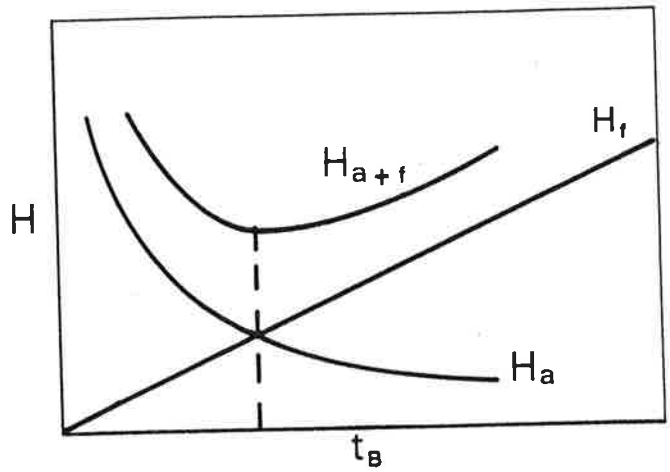

Fig. 5. The combined heat requirement for fabric and ventilation loss shows a minimum value, which occurs near the intersection of the two lines.

3 Conclusions

Poorer insulated houses will have higher values for ΣAU. Simple inspection shows that although they will need more heat to control to 70 per cent relative humidity, that is achieved at a lower temperature than in better insulated homes. Although higher moisture generation rates also lead to higher minimum heat requirements, they do so with higher temperatures.

A number of points are of interest.

(1) The analysis shows that the occupants have two energy needs at the minimum point. One is for the ventilating air and the other for fabric losses and these will be of similar magnitude.

(2) The heat needed to warm the ventilating air is primarily determined by the occupants' lifestyle and consequent moisture generation rate. Thus an increase in moisture, from say drying laundry, will need more ventilation and more heat. Moisture generation rates can be estimated for a range of living styles.

(3) The heat needed to meet fabric losses is determined by the design of the house and so is readily evaluated.

(4) For a given house the minimum heat requirement will change with the number of occupants. In general more

occupants lead to more moisture generation and hence higher minimum heating requirements to control humidity levels and reduce mould growth.

A final point is that the analysis as presented is deliberately very generalised in order to establish the principles. It can be developed to deal with specific housing situations and also the very different types of conditions that occur, for instance, in kitchens, living rooms and bedrooms. Then, by allowing for internal gains and heat transfers, say from living rooms to bedrooms, it will be feasible to identify net minimum heat requirements and heating costs taking account of appliance efficiency, fuel costs and occupancy.

It will also need comparing with experience in occupied housing in order to show the effects of heating, ventilation and infiltration in practice and to see how nearly the minimum energy input approaches comfort requirements as well. The latter are particularly important in living rooms when occupied, and bedrooms when used for living and in housing or the frail and elderly.

Acknowledgement

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