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FIELD AND LABORATORY EVALUATION OF NEW DEVELOPMENTS IN GAS FIRED APPLIANCES TO PREVENT CONDENSATION IN DWELLINGS

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INTRODUCTION

Moisture is emitted into the atmosphere during cooking, clothes washing, personal hygiene and by breathing. A four person household produces between 5 and 10 litres of water vapour per day, rising to 12 litres where clothes drying indoors takes place[1]. This moisture can condense out onto cold surfaces within the dwelling, producing suitable conditions for mould spores to germinate. It is estimated[2] that of the UK housing stock of 17.5 million dwellings, 8.5 million are affected by some form of condensation with 2.8 million having serious problems, often accompanied by mould growth. Although condensation is more common in older, less well insulated dwellings, it can also occur in new dwellings having reduced ventilation heat losses to save energy. A recent survey[3] by BRE of 385 new small homes showed that 50% had pools of water on the window sills due to condensation.

To investigate the interaction between condensation, occupancy patterns and moisture production in well insulated dwellings, computer studies have been carried out for a two bedroom flat with walls having a 'U' value of 0.5 $W/m^2{}^\circ C$ and a heat loss of 2.6kW. The results for a two person household show that even where the moisture production is low (3.6 litres per day) condensation occurs when the house is unheated for long periods and relative humidities above 70%, the critical level for mould growth, will persist for over 5 hours per day. Where moisture emissions are greater, the periods of high humidity persist longer. These computer studies demonstrate that where houses are heated intermittently condensation can occur even though moisture emissions are low.

The mechanism of mould growth is well documented[4] as are the cures. These include decreasing the amount of water vapour being released into the house, increasing the fresh air ventilation rate, increasing the internal air temperature or removing water vapour either at source or with a dehumidifier. British Gas are investigating a range of novel approaches to the problem of condensation, especially in new well insulated dwellings.

COMBINED HEATING AND FRESH AIR SUPPLY

For anti-condensation measures to be effective and acceptable to the householders, it is essential that they do not adversely affect the thermal environment by, for example, promoting draughts. Consequently, where outside air is introduced mechanically it must first be heated before being distributed into the living space. This can be achieved in a number of ways.

Modular Approach

A novel approach is to use a specially developed water to air heat exchanger module supplied by hot water from a thermal store (that also provides domestic hot water) charged by a gas boiler. The Warm Air Module provides not only conditioned fresh air but also the heating requirements of the dwelling. It is specifically designed to be quiet, to ensure that it is used when required and is not turned off by the occupants because of noise. Extensive work in a reverberation chamber has confirmed that its noise level is less than 38dBA. The output is 2.75kW with a boost facility of over 3kW. The module can be supplied either as a basic unit or as a free standing cased room heater.

The Warm Air Module has been evaluated in a 3 bedroomed newly constructed end of terrace house having a heat loss of 4.7kW. Consequently two units, fed from the same thermal store, were installed. A schematic diagram of the installation is shown in figure 1. The upstairs unit was installed in a cupboard on the landing and supplied warm air to all three bedrooms through ducts laid in the loft. Fresh air was ducted into the return air inlet. Downstairs, the free standing room heater was installed in the main living room. It also supplied heat to the adjoining kitchen through a stub duct. The bathroom was heated by a radiator/towel rail connected directly to the thermal store. One advantage of using two modules was that it allowed independent control of the temperature upstairs and downstairs. The test house measurements, see

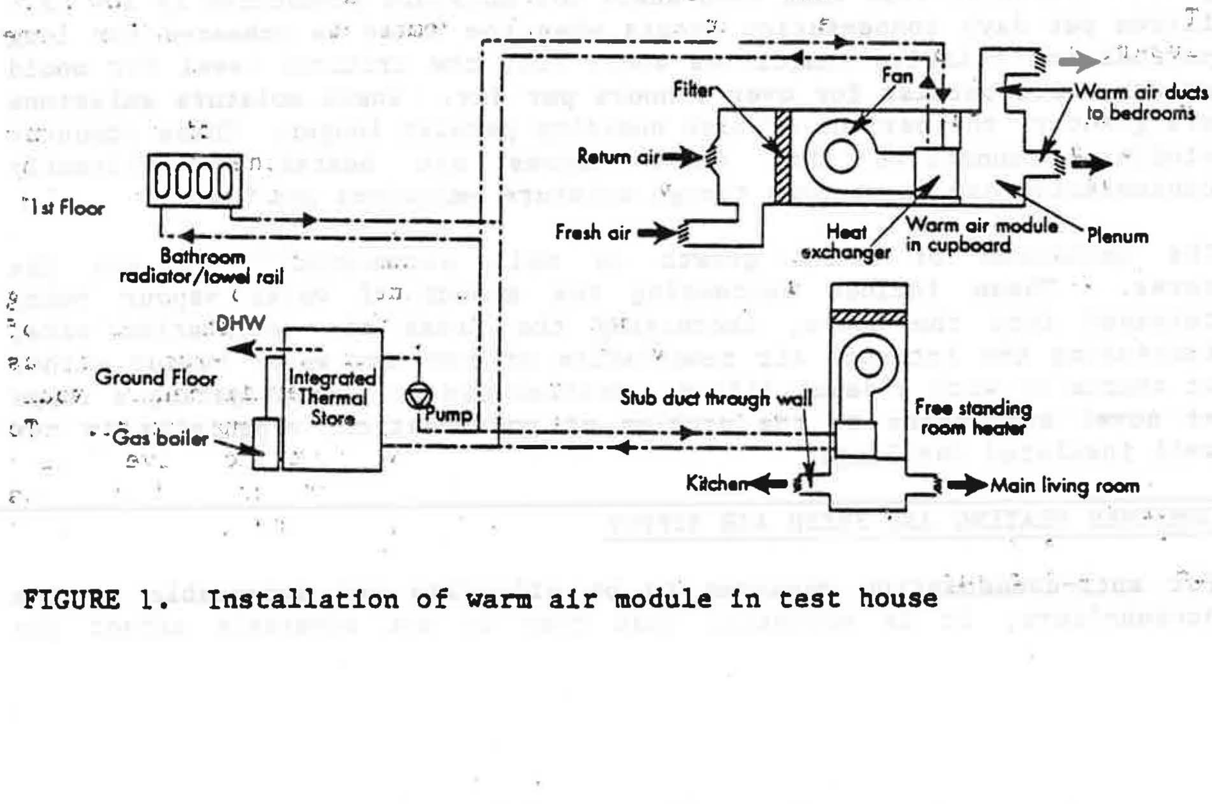

FIGURE 1. Installation of warm air module in test house

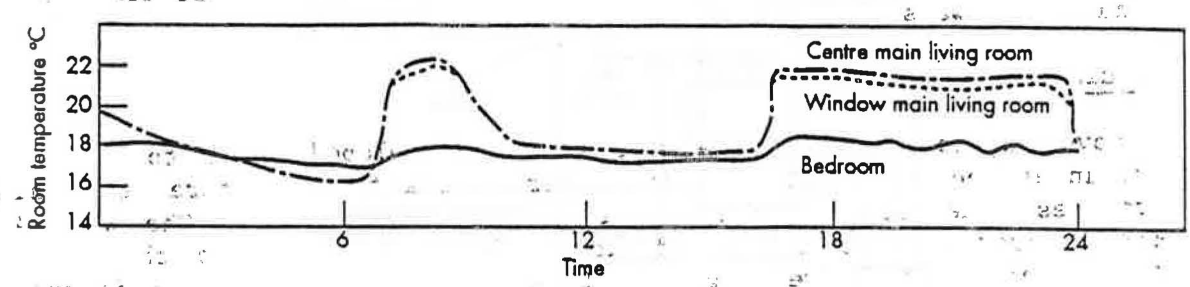

FIGURE 2. Test house evaluation of warm air module.

figure 2, showed that the module provides a rapid warm up with a good distribution of warm air resulting in an even temperature throughout the room. Even in front of the window the temperature was within 0.3°C of that in the middle of the room. The satisfactory thermal and acoustic environments produced guarantees that sufficient fresh, pre-heated air is introduced, especially to the sensitive areas of the house, to prevent condensation.

Mechanical Ventilation with Heat Recovery

A more energy efficient method is to incorporate heat recovery with full mechanical ventilation. For highly insulated dwellings where the heating requirement is small, a water to air heat exchanger can be incorporated into the supply duct of a full mechanical ventilation with heat recovery system. This novel approach was used in a demonstration project funded by the European Community[5]. Four superinsulated houses with heat recovery, and eight control houses without any form of mechanical ventilation, were built from components imported from Finland. The three bedroomed houses are identical except for the standard of insulation. The control houses have a heat loss of 4.5kW compared to only 2kW for the superinsulated ones.

The ventilation system is powered by a heat recovery and ventilation unit situated in the kitchen (Figure 3). The temperature of the fresh outside air, pre-heated in the heat recovery unit, is further raised by the water to air heat exchanger to compensate for the dwelling heat losses. With the average useful miscellaneous heat gains being of the order of 700W, there will be little heat demand for significant parts of the heating season. Consequently a crucial part of the design is the method of controlling the heat supplied by the water to air heat exchanger, as failure to control the small fluctuating heat requirements would inevitably result in wide fluctuations in supply air temperature. To ensure good control of the thermal environment, without excessive boiler cycling, the heat exchanger is fed from a thermal store, charged by a gas boiler. The temperature of the water flowing to the unit is then continuously modulated by a room thermostat operating on a 3-port valve in the water supply to provide the exact heat requirement.

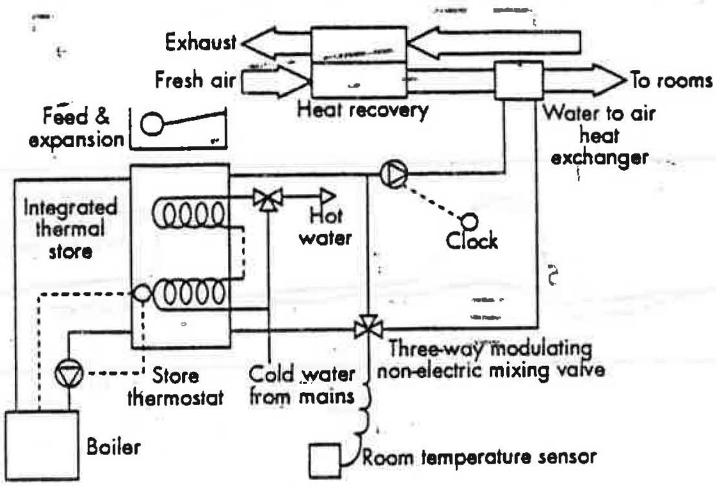

FIGURE 3. Heat recovery system for superinsulated homes

The performance of the houses has been extensively monitored. On average, the control houses used 56.2GJ per annum for heating and hot water compared to only 33.4GJ for the superinsulated homes. Of the energy savings approximately 8GJ could be attributed to the heat recovery system. Not only were fuel bills lower, but the occupants of the superinsulated houses had an enhanced thermal environment[6]. None of the superinsulated houses suffered from any form of condensation anywhere in the house. By contrast, all eight control houses suffered condensation on the windows even after slot ventilators had been added to the window frames.

Heat Recovery from Flue Products

British Gas are further increasing energy efficiency by developing a system that incorporates heat recovery from flue products[7]. The flue from a conventional gas boiler or air heater is connected into the extract system and the flue products pass through the heat recovery unit,

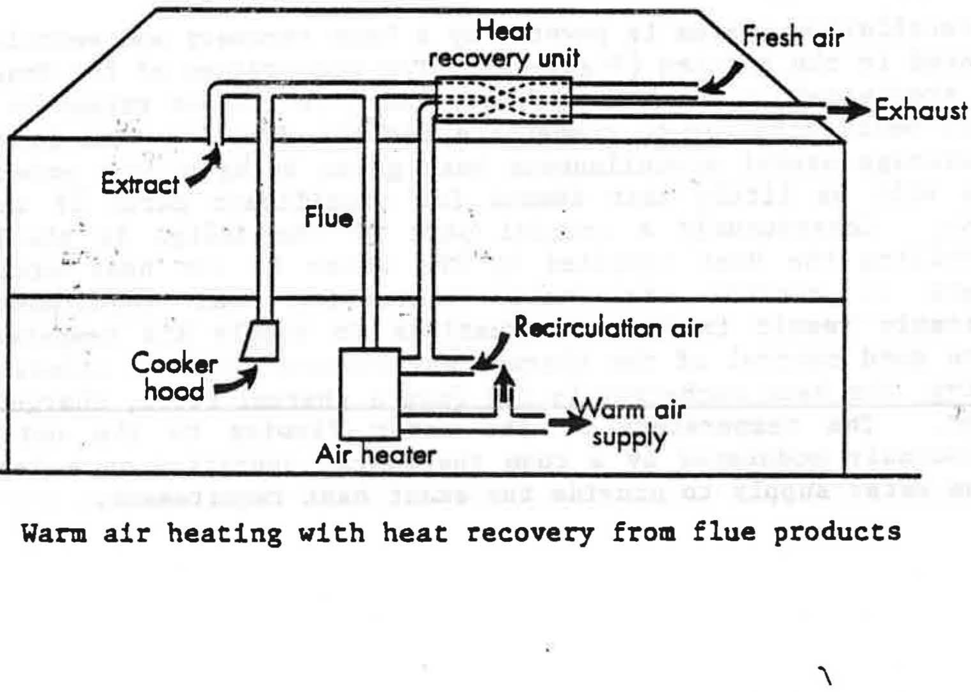

FIGURE 4. Warm air heating with heat recovery from flue products

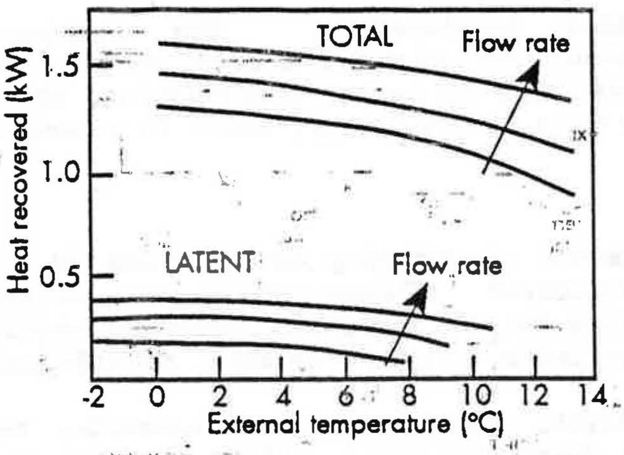

FIGURE 5. Variation of heat recovered with external temperature

so that the heat in the flue products as well as that in the extract ventilation air can be used to preheat the incoming fresh air. This heated air can either be used to provide background heating where a radiator system is installed or fed to the inlet duct of a warm air heater as shown in figure 4. The warm air version was tested in the same house used for the tests on the Warm Air Module and some of the results are shown in figure 5. The total heat recovery rate rises as the external temperature falls, reaching 1.5kW at 0°C. Since the latent heat of the water vapour in the flue products is also reclaimed, the heater becomes, in essence, a condensing appliance. Heat is also reclaimed from domestic activities with 1.2kW of the 3kW released by the cooker being recoverable.

A number of field installations are being monitored. Seven installations have a warm air heating system whilst two are based on radiator heating. Initial customer response has been very encouraging. The provision of a controlled supply of thermally conditioned air has almost completely eliminated condensation on even single glazed windows and there have been no adverse comments on draughts or of poor air distribution.

BACKGROUND HEATING

Local authority blocks of apartments are prone to condensation because they have inefficient heating systems which are not regularly used by the occupants. Consequently, the dwellings are cold and damp, a condition aggravated by the frequent use of unflued bottle gas heaters. Field trials carried out by the Building Research Establishment[4], have shown that installing a gas central heating system can, by providing a warmer internal environment, completely eliminate condensation problems. However, it is not always possible to install individual gas heating systems in high rise blocks of apartments. In these cases, communal systems can be installed whereby one central boiler supplies heat to each individual apartment. To meet this demand a new gas fired group heating system based on integrated thermal storage units that incorporates an element of continuous background heating under the control of the landlord has been developed[8]. The combination of landlord controlled background heating and a metered heating circuit ensures that heat is always available to combat condensation, but because the tenant pays directly for most of his energy, waste is minimised.

DEHUMIDIFIERS

An alternative method of reducing condensation is to remove the water vapour by a dehumidifer. Dehumidifiers are suitable for use where structural upgrading is not possible, increased heating is not economic and increased ventilation would be wasteful or difficult to achieve.

To date, all domestic dehumidifiers are electric, however a gas fired unit based on the absorption cycle, offers a number of advantages. A gas dehumidifier has no moving parts and therefore is quieter in operation and more reliable. It does not use CFC refrigerants and has lower running costs. Additionally, a gas dehumidifier provides background heating which helps to alleviate the problem. Watson House are currently carrying out feasibility studies on gas dehumidifiers.

CONCLUSIONS

Condensation and mould growth is a serious problem in 2.8 million homes in the United Kingdom. British Gas are actively pursuing energy efficient methods of combating it. The methods include mechanical ventilation with or without heat recovery, warm air ventilation modules supplied from thermal stores and communal heating systems with landlord controlled background heating. The development of a gas fired dehumidifier based on the gas absorption cycle is being considered.

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