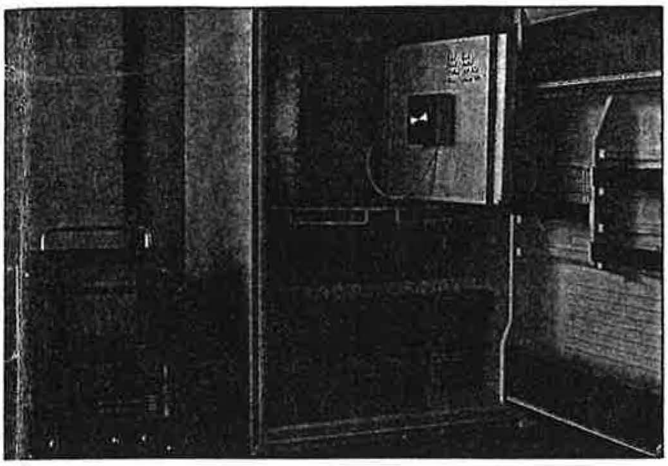
Improving trv control

Richard Palmer describes how a small alteration to a thermostat enables it to hold a constant temperature despite a sharp fall outside.



Above: A fridge being used as an environmental chamber with model room inside. The Comark thermocouple scanner is interfaced to a BBC computer which acts as a logger and also controls the fridge temperature by a fan convector heating element.

Mechanical room thermostats fail to maintain a constant room temperature in two ways: the temperature cycles up and down as the thermostat cuts in and out, and the room temperature is influenced by the load on the heating system.

However, a mechanical thermostat can be modified cheaply to reduce both variations, enabling £10 mechanical thermostats to challenge the performance of £40 electronic thermostats.

Current practice is to use an accelerator to achieve fast cycling. This is an electrical resistor mounted close to the bi-metallic strip. It is wired to dissipate about 150 mW while the thermostat is calling for heat, thus warming the thermostat in anticipation of rising room temperature, encouraging it to cut off heat early. Accelerators are very effective at achieving fast cycle rates and their use is only curbed by the fact that they increase compliance.

Room temperature is influenced by the load on the heating system. Simple survey work shows that of those who have a thermostat in their home, over 75% find it necessary to turn up the thermostat in cold weather. This is compliance, or "the drop in mean controlled temperature as the heating load increases from 20% to 80% of the available power" – and is due partly to the use of an accelerator.

As an accelerator is energised while the thermostat is calling for heat, it is energised for a high proportion of the time during cold weather. Thermostat warming during cold weather causes a depression in room temperature. For example, if the thermostat keeps itself at a constant temperature but is 3°C above room temperature in cold weather, then room temperature will be depressed by the same amount.

Compliance is also due to thermal inertia of the thermostat, and delay in the response of the heating system. The thermostat temperature follows the up and down cycles of room temperature, but with a lag time. When the thermostat reaches the temperature where it will switch the heating back on, the room is already below the temperature limit.

In cold weather this problem will be worse simply because room temperature will fall more rapidly and so reach a lower temperature before the heating system can respond. Any delay in the supply of heat to the room due to slow response will increase compliance for the same reason.

Thermostats can be modified to eliminate compliance. If a normal trv were set to provide the desired room temperature when it is cold outside, room temperature would rise as the weather became milder. The modified thermostat has an additional internal heater which progressively warms the thermostat as the weather becomes milder, so maintaining a constant room temperature.

The additional heater is a 0·5 W resistor wired across the thermostat contacts so that it is energised when the thermostat is not calling for heat. It is located behind the thermostat chassis so that the heat transfer time to the bi-metallic strip is long compared to the cycle time of the thermostat. This prevents the additional heater from reducing the rate of cycling as it is acting in anti-phase to the accelerator heater.

There are no changes to the installation requirements provided the new leakage current of 2 mA can safely drain through the load while the thermostat contacts are open. This current will present no problem where the thermostat is switching a pump, but care should be taken if it is switching a gas valve as the leakage current would prevent the valve closing reliably.

Computer simulation was carried out to test these theories. The simulation correctly predicted that compliance could be eliminated, but it overestimated the cyclic variation by 100%. (Perhaps such variation could occur in a lightweight room?)

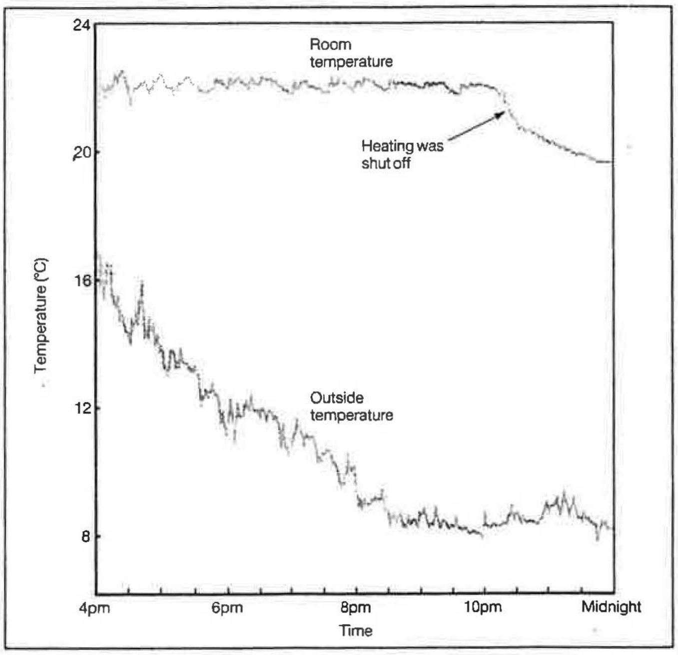
Secondly a model room was constructed so that real thermostats could be tested, operating against real, as opposed to theoretical, temperature fluctuations. The main reason for doing this was to enable consistent results to be measured, ie free from disturbances typically found in households, along with a controllable weather pattern. Trials were run first to tune the trv by the selection of suitable resistor values.

Results from the model room tests were encouraging: compliance was completely eliminated and cycling only increased slightly.

The final test was to run the modified trv in a house. As can be seen from the results, compliance was totally eliminated. The emitters used were finned skirting radiators, so it was surprising that room temperature continued to rise for around ten minutes after the pump was stopped by the thermostat (timing varying with the coldness of the outside temperature). If the emitter response was longer (to be expected from panel radiators) then the quality of control would suffer with any type of thermostat.

The modification has yet to be properly tested so it would be unwise to promise greater comfort for all mankind. It should reduce the need for people to adjust their controls and be especially welcome to those whose environment is controlled by a tamper-proof thermostat. It may even help to save energy, but this is another point for discussion.

Richard Palmer CEng MIMechE MIProdE is a senior lecturer at the Herts Centre for Building Studies, St Albans. He is investigating thermostats for an MPhil research degree.



Above: Temperature log showing ability of modified thermostat to hold room temperature constant despite a sharp increase in heating load.

