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Heat recovery

It's in the air

by Steve Irving and Ian Smith

The second part of our feature looks at air-to-air heat recovery. A CIBSE Research Fund project is attempting to unravel the mysteries surrounding such devices, and here Steve Irving and Ian Smith give us a taste of what's to come.

The CIBSE Research Fund has commissioned a project, under contract to Oscar Faber Applied Research, to examine the performance and application of air-to-air heat recovery devices. The first part of the project, a review of published literature, is outlined here. This review will be complemented by an analysis of performance using simulation and field measurements.

The purpose of the review is to discover the range of expected performance of three types of heat recovery systems, namely run-around coils, plate heat-exchangers and thermal wheels. The review combines an analysis of manufacturer's data with any information gleaned from documents such as journals, guides and research papers.

The survey has been pursued with specific emphasis on the following areas:

☐ system effectiveness (sensible and latent, where applicable);
☐ the likely changes in air-side pressure drop due to the installation of a heat recovery system;
☐ any auxiliary power consumption (eg by fans, pumps and motors);
☐ possible cross-contamination between supply and exhaust air flows;
☐ additional plant room and general space requirements, including the need for adjacency in supply and exhaust ductwork.

In addition, the full review also assesses costing and maintenance issues of key importance to designers.

System effectiveness

System effectiveness and pressure drop are the foremost means of defining the energy performance of any heat recovery device. The effectiveness is dependent on several parameters such as the supply and exhaust flows and the energy transfer characteristics of the device.

Some general rules have been extracted for optimising effectiveness. These are:

☐ the lower the proportion of flow-to-design flow passing through the device, the higher its effectiveness will be;
☐ higher effectiveness will coincide with a small supply/exhaust ratio (ie $<1\cdot0$);
☐ the lower the velocity of the air passing over the device the greater the effectiveness.

For a full evaluation of a system's efficiency, account must be taken of the additional fan, pump and motor energy required by the system.

Figure 1 provides an indication of the range of effectiveness encountered for all three types of heat recovery device. The typical situation of supply air being 10% greater than the exhaust has been assumed for each case.

It can be seen that thermal wheels consistently show a higher effectiveness than the other two types of device. The effectiveness of plate heat-exchangers appears to be similar to that of run-around coils, but with a slightly wider range of values.

Airside pressure drop

Where a heat recovery device is placed in an airstream there is a pressure drop across it because of the resistance it offers to the flow. This inevitably leads to greater use of electricity as the supply and extract fans have to develop larger total fan pressures. Predominantly, pressure drop will increase with face velocity.

Figure 2 gives an indication as to the range of pressure drops likely to be encountered with the various types of device. The values combine both supply and exhaust pressure drops.

Coefficients of performance

All heat recovery devices will place an additional load on the supply and extract fans. In addition to this, there is a further electrical load for run-around coils (for the pump) and thermal wheels (for the motor).

In order to make the most economic use of any heat recovery device, the various components should be sized at the design stage to suit the needs of the plant. This will ensure that the installed power of the refrigeration and heating equipment can often be reduced, thus lowering the cost of the investment.

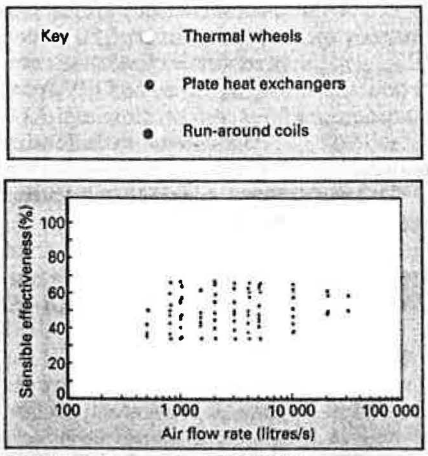


Figure 1: Comparison of sensible effectiveness plotted against air flow rate (supply).

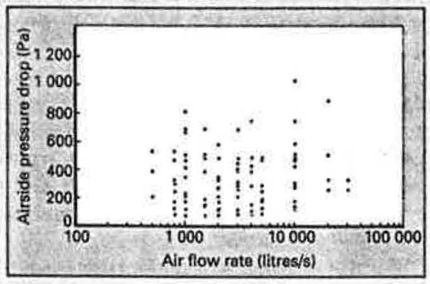


Figure 2: Pressure drops encountered against air flow rate.

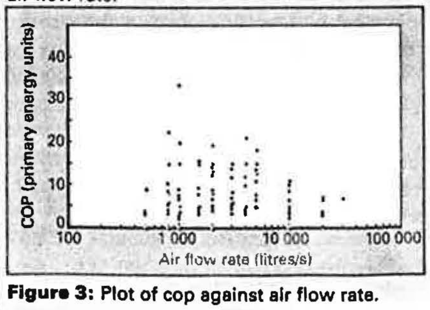
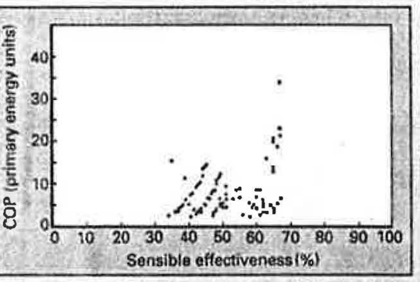


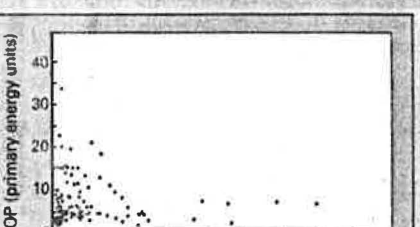
Figure 3: Plot of cop against air flow rate.

Figure 3 presents a coefficient of per- rmance (cop, measured in primary nergy units) for each device. The values present the ratio of sensible heat re- overed divided by the extraneous fan ower, in addition to the extra pump or otor power.

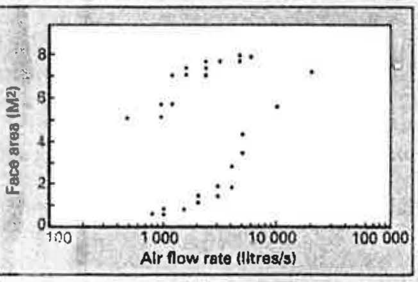
To indicate the rating of devices, the ffective cops have been plotted against nsible effectiveness for each device (see gure 4). The graph indicates the general periority of thermal wheels, providing igher effectiveness and at a better cop an the other two types of device.



igure 4: Plot of cop against sensible ffectiveness.



igure 5: Plot of cop against heat recovered.



igure 6: Comparison of typical sizes of face reas at various air supply flow-rates.

Figure 5 indicates the possible connection between cop and energy recovered. It is apparent that, while there are no glaring trends for any of the devices, the higher cops are associated with the lower levels of heat recovery. It can also be observed that, in general, the cops for thermal wheels are greater than for those of plate heat exchangers, which are in turn greater than those for run-around coils.

The consideration of the likely space penalty within the plant room must include not only the space encompassed by the device, but also any adjustment required in the ductwork that is necessary to bring the supply and exhaust ducts together, or to reduce air velocity through the device.

Figure 6 is based on information from a single manufacturer and shows only face area values. However, it does show that for low supply rates, run-around coils take up least space in the airstream. But at higher volumes a run-around coil is likely to encompass more space than a thermal wheel. Generally, plate heat-exchangers require the least space in the duct.

Steve Irving and Ian Smith are with Oscar Faber Applied Research.

Making a full recovery

by Chris Twinn

Heat recovery devices are often ruled out in conventionally-designed buildings on economic grounds. Chris Twinn argues the case for a more considered approach to plant design and looks at the benefits of 100% fresh air supply.

There are often many conflicting considerations when it comes to selecting air plant and associated components. First, there are the client's main objectives, which may be to achieve a basic internal climate at minimum cost, ensure the satisfaction of his employers or to create a landmark using the best practical quality.

Second, there are considerations based on the areas served, for example different uses, varying fresh air requirements or durations, and different levels of heating and cooling. Air-to-air heat recovery is influenced by all of the above.

Fresh air

The easiest and cheapest form of air-to-air heat recovery is the recirculation of return air. This process can recover up to 100% of the return air's heat for only the investment of a mixing chamber. However, the conflicts begin with the requirement for a proportion of fresh air.

For an air plant supplying 25% fresh air to an office, the availability of up to 75% recirculation of internal heat gains satisfies the fresh-air heating requirements for a vast proportion of the year. The chances of justifying heat recovery between exhaust and intake are then very remote. The occasions when the small amount of heat in the exhaust is required to supplement the recirculation are very few (see table 1).

If the application requires larger proportions of fresh air, the arguments for heat recovery devices increase. With 100% fresh air it becomes almost essential (see table 2). Then it is a matter of choosing the devices most suitable for the building, in the usual efficiency pecking order of thermal wheel, plate heat-exchanger and run-around coils.

Internal heat gains

As internal heat gains increase, so will the proportion of the year where heat recovery can satisfy fresh-air heating requirements. In effect, the electricity used by office machines can be employed a second time for heating the fresh air.

This can produce useful reductions, and very occasionally the elimination of the