A new era for indoor climate

*** Dr. Ing Uwe Schulz explains the REDCO system for indoor control**

In the late 80's, a Swiss research organisation was approached to re-assess the whole idea of air conditioning in light of a newly perceived objective for such installations. This was the creation of a complete indoor climate in which more criteria needed to be considered than just the renewal of room air and the removal of heat gains. Furthermore, it was clear that the random method by which these two processes were often designed and operated as totally separate systems was responsible for much of the dissatisfaction with air conditioning being widely expressed at that time.

Above: a combination of cooled ceilings and displacement ventilation can be just the ticket for a comfortable indoor environment

In addition to a general re-definition of indoor air quality, stricter codes of practice in respect of air movement velocities had been introduced in Germany and Switzerland which had the effect of rendering inappropriate many hitherto accepted methods of air conditioning.

One further factor of importance was the more realistic approach being taken towards cooling loads. It was accepted that over-estimation of cooling loads together with the failure to limit fabric gains at the design stage had led not only to excessive capital and operating costs but also to poor system control.

The REDCO concept

The Swiss researchers immediately recognised the need for an integrated approach for the evaluation and design of each component of the air conditioning and that positive use must be made of the thermal dynamic characteristics not only of the conditioned space but also of its occupants and contents. For this to be achieved, total responsibility for the indoor climate system had to be assumed by a single supplier yet, at the same time, sufficient flexibility needed to be retained within the design concept to accommodate the individual requirements of the architect, the design engineer, the project management and, not least, the building owner.

The result of this design study is a method of indoor climate control which combines radiant cooled ceilings with a laminar flow system for the supply of fresh air and the displacement of heat gains known as REDCO (Radiant Energy Dynamics for Comfort). Its development and general design details are described below.

Air renewal

The condition known as "Sick Building Syndrome" has given rise to considerable research activity concentrating on the harmful substances encountered within the building itself. However, the charge of deleterious material in the indoor atmosphere ranges from the simple water vapour and CO_2 produced by human occupants through to complex noxious gases emanating from the building structure and fittings. Because both the charge levels of these contaminants and the outdoor air concentration of CO_2 vary, differences still exist as to the recommended minimum air quantity for each occupant.

However, there is general agreement that a room air change rate of 2.5 to 3 times per hour is to be recommended and it will be possible to further increase ventilation efficiency if the appropriate fresh air quantity can be brought directly to where it will be inhaled by the room occupants. Such a solution is offered by displacement ventilation in which the vitiated air is not allowed to mix with the fresh air but is evacuated at the upper level of the room. With laminar introduction of air at low level into the room and the exploitation of thermal currents naturally generated by the heat emitted by the human body and other heat sources, the quality of supply air received is perceptibly improved and draughts avoided.

Whilst the continuous emission of body heat creates a lift rate of air at head height in the order 0.25 m/s, the air approaching onto a person should be free of turbulence and at a velocity not exceeding 0.15 m/s. This requirement can be achieved with a displacement ventilation system but one which will only provide the removal of room heat gains up to 30-35 W/m^2. Even with the more realistic approach to heat gains, this level cooling is unlikely to be adequate for an average office environment.

Heat gain removal

A method is required for providing the extra cooling needed without compromising the room condition achieved with

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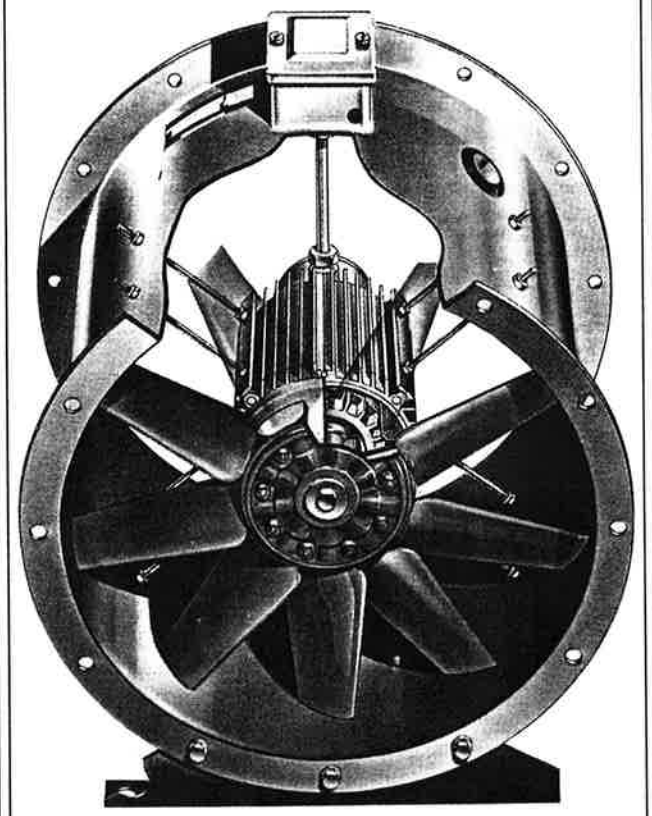

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the displacement system as described above. Increasing the air flow volume is clearly not an acceptable option if the limit of 0.15m/s is to be maintained. Similarly convective cooling elements, even if not fan assisted, may set up air movement patterns in which the critical air speed is likely to be exceeded. In addition, natural downward convection may tend to work against the natural displacement effect which is an essential part of the fresh air supply system. Whilst this may be overcome by careful location of the cooling elements in respect to the known heat sources, the system then loses much of its flexibility in use.

Nearly half the heat emitted by the body is by radiation and it is when this heat balance is achieved that an individual will feel most comfortable. Most other heat sources will also be capable of heat dissipation by the same means. The logical solution to providing extra cooling must surely be the combination of displacement ventilation with the removal of heat by radiation.

The ceiling is both the obvious and ideal choice for the radiant surface, particularly as it can be cooled by both air and water. Selection of the heat transfer media will be on the basis of a number of parameters, including investment and running costs, and the cooling capacity required from the system.

Development

For maximum comfort and the minimum use of energy, the surface temperature for the ceiling surface should be as high as possible. In the development of the REDCO system, this important criteria was met by following these guide-lines:

- By leaving 15% free access through the ceiling it is still possible to exploit the storage capacity of the building mass thereby reducing the output required from the ceiling system.
- By mounting the chilled ceiling elements at a specific distance below the slab, the entire peripheral surface area of the cooling element can participate in the heat exchange process.
- For both its thermal conductivity and adaptability to a flexible design concept for the ceiling, aluminium was the chosen material for the REDCO system elements.
- To achieve optimum heat flow from the element surface passageways for the cooling media, whether for water or air, are incorporated into the REDCO extruded aluminium elements.

The system

With both components of the REDCO system operating in combination with the thermal dynamic characteristics of the conditioned space and its occupants, the efficient evacuation of both building pollution loads and heat gains is assured. Extensive laboratory testing has shown that the REDCO system for indoor climate control will perform successfully over a wide and exacting range of operating conditions.

A variety of buildings can now benefit from the agreeable environment it provides in combination with a minimum use of energy.

Choice of heat transfer media

Whilst it is accepted that water is many times more efficient in terms of energy and space for the transportation of heat than air there will be instances where, despite this apparent discrepancy, air will be the preferred choice as the transfer fluid in a REDCO system.

The choice of heat transfer media – water, air or a combination of the two – will be determined on the basis of the cooling loads and the architectural and technical requirements of the project.

REDCO-Water will normally be the first choice system because of its higher cooling capacity. A more compact installation can also be achieved with the possibility of a minimum ceiling depth of only 100mm.

The requirement for only a single distribution system for both air renewal and cooling, and the absence of pipework within ceilings voids are recognised as the major benefits to be gained from the use of the alternative REDCO-Air system.

Water

Capable of removing more than 100 W/m^2, the REDCO-Water system has been applied successfully over the full range of range of heat gains from 40W/m^2 upwards. Depending on this peak heat gain , the chilled elements will occupy no more than 30-60% of the ceiling surface area with the remainder being available for lighting, acoustic and decorative panels. Even in applications with the maximum output, the cooling surfaces installed are rarely more than 60% of the total area. Because of the fully integrated controls on one hand, and the efficient use of the heat transfer process on the other, cooling surface temperature levels will remain well above the room air dew point, eliminating any risk of condensation.

Air

Intended primarily for low energy buildings, REDCO-Air systems have, nevertheless, been successfully applied where cooling loads have been in the order of 40-50 W/m^2. The chilled ceiling elements will normally be served directly from the supply air system although a closed circuit air circulation is also a possibility.

Where supply air is to be used, it is warmed as it passes through the chilled ceiling elements and then discharged into the conditioned space via laminar flow outlets. With controlled humidity and exhaust air extraction via luminaires, the REDCO-Air system is capable of ensuring a draught-free evacuation of heat gains with temperature differentials of up to 18K. Compared with a conventional air conditioning system, the lower air flow quantity results in energy consumption being reduced by up to a half.

Bi fluid

A combination of both types – REDCO-Air and REDCO-Water – this system offers all the advantages of the two. Water is the predominant heat transfer media and the REDCO-Air portion is normally limited to the supply air design requirement only. However, in winter and during the mid-seasons, when outdoor air is being used directly for free cooling, the contribution from the REDCO-Water elements can be reduced or eliminated entirely.

Flexibility of choice

The flexibility of REDCO systems extends beyond a choice of heat transfer fluid to the visual aspect of the exposed surface. This can be made to match the architectural requirements with no upper or lower limits to the mounting height for the ceiling. The placement of luminaires will not effect air movement within the occupied zone of the room.

The chilled ceiling elements are supplied individually or pre-assembled into modules depending on which provides the easier method of installation for a given application.

Ceiling modules

REDCO elements in extruded aluminium can be supplied in widths of 100 to 250mm and lengths up to 7500mm. These aluminium profiles are electro-powder coated in accordance with the "Qualicoat" requirements for quality and colour sample range. Normally the finished elements are integrated with matching acoustic panels into chilled ceiling modules and delivered pre-assembled ready for mounting. REDCO-WATER elements within a module are pre-connected to provide a single inlet and outlet.

Laminar outlets

REDCO laminar flow outlets for both ceiling and floor mounting can supplied for use with REDCO chilled ceilings. Designed for minimum turbulence and entrainment of room air, they provide the displacement ventilation effect which is an indivisible component of the REDCO integrated system for indoor climate control.

REDCO laminar ceiling outlets are available in a variety of configurations and surface treatments. All are capable, however, of transferring the supply air to low level for displacement diffusion at velocities well with the required limit of 0.15 m/s.

The REDCO type PDB outlet is a true displacement floor diffuser intended for a maximum duty in the order of 20 l/s. The square diffuser plate is in perforated stainless steel and the unit can be supplied with a mounting flange and carpet trim in the same material.

Good control of the total indoor climate is recognised as being essential for the high levels of occupant efficiency needed for today's competitive world. REDCO, with its logical combination of dynamic and static elements offers the building owner the opportunity to achieve this goal.

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