AN AIR HANDLING UNIT FOR THE NEXT CENTURY - PART 2
The Factor 4 in Air-Conditioning

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Introduction

Part 1 of this Paper describes a new concept for an AHU and presented estimates which demonstrated that doubling the air quality and halving the energy consumption is feasible with this Next Century Unit. Part 2, presented hereby, comprises a more detailed description of this Unit.
The construction, set up and connections of the proposed Air Handling Unit are described in Part 1.

The mixing Section

In the mixing section, the return air is 100% discharged to the outside or 100% recirculated with mixing options from 0 - 100% vice versa. Discharge of exhaust air has to be carried out without the risk of short-circuiting. See Part 1

The mixing process is automatically controlled by the three motorized multiblade dampers as follows:

- Enthalpy Control: Outdoor Air is supplied in such quantities that free cooling is optimized and energy consumption minimized.
- Minimum Outdoor Air Control, set at app. 2.500 PPM $C0_2$in the return air.
- Minimum Outdoor Air control in periods of electric peak-loads in order to avoid overstepping the maximum contractual loads with the inherent penalties.
- R.H. control in order 10 ensure that the relative humidity of the mixed air does not exceed 90% R.H. This is a very important condition for the well-functionary of air cleaners, both mechanical and electronic types. In case of very humid outside air, for instance during fog periods, sufficient return air is mixed to the outdoor air to keep the R.H. below 90%.
- Outdoor air shut off when the building heats up, and during periods of severe outside air pollution which could occur in case of calamities.

Efficient mixing of return air and outdoor air is not very easy. In our design mixing is optimized by a special device, consisting of a panel with multi whirl diffusers, which at the same time guarantees an even flow to the next section. This is a very important condition for the well-functioning of the electrostatic air cleaner.

Inspection- and Maintenance Section

Au inspection and maintenance section, provided with an admission door, electric lighting and an observation hole is installed between the mixing section and the electrostatic air cleaner.

The electrostatic (ES) air cleaner

As pointed out before, mechanical air filters are not capable of "catching" the very fine dust particles which are often saturated with noxious substances from the outdoor air. Moreover, these filters emit disagreeable odours and can form a good matrix for microbiological growth. Research bas shown that mechanical air filters constitute the greatest polluters in air-conditioning systems [10,11,12].

What we need is an air cleaner with a high and constant efficiency, that is periodically cleaned, does not emit odours and does not give any opportunity for microbiological contamination. The ES air cleaner with cleaning device meets these requirements.

ES air cleaners are composed of an ionisation section and a collector section, while a coarse front filter keeps out insects and the like. In the ionisation section, the dust particles are given a negative electric charge. In the collector section the dust particles are attracted by collector plates with a positive charge and dust removed from the air stream. Automatic cleaning of the filter is possible.

The advantages of ES air cleaners compared to mechanical filters are the following:

- Odour emission and microbiological growth in the filter do not occur.
- Tobacco smoke, pollen, bacteria, black smoke and the like are effectively separated owing to the high efficiency.
- Microbiological pollution like bacteria are not only separated, but also "oxidized" or burnt by the ozone formed in the high tension field.
- Many organic odorants are also "oxidized" by the ozone formation and the conversion from O_3 to O_2 ,making the air fresher.
- More air can be recirculated because of the superior cleaning of the air.
- Because the pressure loss is constant, fan power and energy consumption is reduced.
- Maintenance costs are lower because there is no need to replace f1lter cells.
- The cleaning device prevents problems with the disposal of the large number of used filter cells.

The high investment costs of ES air cleaners constitute a impediment for application in air handling units. Preliminary life cycle costs calculations however indicate that payback periods are attractive. Further analysis is needed to prove this [13].

The often mentioned disadvantages of ES air cleaners, viz. ozone production and breakthrough of clotted dust are eliminated in the cooling washer described hereafter, Sensitivity to an even air distribution and humid air is eliminated by the construction and the control of the mixing section described earlier.

Heating coil

The heating coil is upstream and downstream provided with an inspection and maintenance section as described earlier. Even though, pollution of the coil us virtually impossible, a regular inspection of the coil is important. The downstream section serves as a supply section for the following plenum-fan as well.

Supply Plenum Fan

The plenum fan is a direct driven centrifugal fan with backward curved blades without housing, electronically controlled by frequency control. The air is discharged in the plenum, ensuring an even air distribution to each connection side of the plenum, thus forming an ideal reversal section in the air handling unit, if required.

Plenum fans constitute a rather new technology in air handling systems. In comparison with traditional centrifugal fans, the following advantages can he mentioned:

- No dynamic pressure and consequently no dynamic pressure losses.
- No V-belt transmission and consequently no transmission losses and pollution of the downstream sections and supply ducting by rubber dust.
- Little fan maintenance and excellent cleaning opportunities; in practice cleaning will be virtually superfluous because of the highly efficient air cleaning described earlier.
- Shorter Plenum section
- Generally less noise production in the lower frequencies.
- Excellent opportunities for Demand Controlled and Variable Volume Ventilation systems.

Generally, the total fan-efficiency is somewhat lower compared with traditional fans but this is compensated for by the fact that no dynamic pressure and transmission losses occur. Up to 1.250 Pa Plenum Fans operate generally at the same total efficiency or better as centrifugal fans with housing. (In the example Part I 60% vs 55%).

Electric Motor

The plenum fan is directly driven by a high efficient switched reluctance electric motor, improving motor efficiency by app. 3 %. The high efficiency of switched reluctance drives can he maintained throughout a wide range of torque and speed [14]. This is exactly what we need for variable volume and Demand Controlled Ventilation Systems.

Noise Control

Normally fan noise is controlled by sound absorbers, consisting of acoustic baffles mounted in a separate unit section. These so-called passive silencers increase the pressure loss of the AHU and create even some additional noise through the obstruction to the air flow. This type of silencers is not very effective in the low frequency bands, and in fact the size of the acoustic baffles- is determined by the low frequency noise.

In the Next Century AHU, the above mentioned plenum fans produce less noise in the low-frequencies. Less noise is also produced because of the lower internal pressure loss and besides the remaining noise is electro-acoustically controlled by a so-called Active Silencing System (ASS). A microphone is mounted near the source of the offending noise with a loudspeaker at a specified distance downstream.

The microphone inputs the unwanted noise to a controller which then drives the loudspeaker with precise, equal and appositive noise-cancelling energy. A second microphone resides downstream of the loudspeaker and inputs residual noise to the controller. The system dynamically compensates for such fluctuating parameters as fan velocity and rate of flow. This Active Silencing System is very effective in cancelling low-frequency noise [5]. Especially this kind of noise affects the human comfort in the indoor environment [16].

In our design the above ASS is integrated into a conventional passive sound absorber consisting of an internal insulated sheet metal duct. The duct liner is encapsulated with an impervious, watertight material to meet all IAQ guidelines.

The Cooling Washer

Air-cooling and dehumidifying in AHU's is normally realized in a coil section which contains one ore more cooling coils. An eliminator after the coil prevents condensate water carryover. The combination of cooling coil and eliminator presents a considerable pressure loss, which can be reduced by a lower face velocity. Reducing the face velocity , however, also reduces the efficiency of the eliminator and increases the carryover of water aerosols which can result in corrosion problems and microbial pollution.

In the Next Century AHU, a multifunctional air washer is installed, provided with a two-stage spray-bank. Instead of an eliminator, a filter bank EU6 is provided, corresponding to app. 75% efficiency (ASHRAE 52-76). This filter, which contains a synthetic filter medium, improves the contact between air and water and stops water aerosols effectively. UV radiation can be applied to ensure the hygiene of the system

The main features of this air washer are:

- Cooling dehumidifying and humidifying through direct contact between air and water.
- Gases such as Ozone, including ozone production of the ES filter, SO_2 and other water-soluble gasses are effectively absorbed by the water. The washer is therefore an excellent smog filter.

The operation of this washer can, in many respects, be compared to a thunder shower. Cold and UV radiated ozone-rich water, cools and improves the quality of the air.

In order to prevent microbial contamination all the water is drained and the washer is blown completely dry before the AHU stops.

Active Air Deodorizing (Optional)

In airport regions and some other areas, the supply air has to be deodorized. Often activated carbon filters are used for this purpose. The operating costs of these filters are high, partly through the need for regular replacement of the carbon cartridges or cells, partly through the pressure losses and inherent power consumption.
Moreover, and this is essential, activated carbon filters may remove pollutants from the air but at the same time constitute a severe pollution load [17].

This is due to the continuous absorbing and desorbing effects in activated carbon (sink and source effects).

A new technology uses an air purifying liquid, which has the property to neutralize odorants by combining with them to a non-odorous complex. This principle of deodorizing rests also on neutralizing disagreeable odours and not on masking or dominating them [18].

Active Air Vitalizing (Optional)

According to some researchers the natural quality of air is "killed "during the process of air-conditioning in an AHU. By adding natural fragrances in a very low dose, below the human observation limits, the air gets its natural quality back, thus realizing an *olfactorical comfort.* Next to thermal, acoustical and visual comfort this is considered an important factor for human wellbeing [19,20]. The distinction between Active Air Deodorizing and Active Air Vitalizing is that the former is essentially a removal process while the latter actually puts something back.

Return Plenum Fan

The return fan with its noise control system is essential identical to the supply fan as described earlier.

Figure 2 shows a dimensioned drawing of the Next Century Unit. For comparison Figure 3 shows the traditional unit. Both units are based on an air volume of 4,0 m^3/s and an air velocity of app. 2,0 m/s. Note the difference in total length.

Legend

1. Mixing section	8. Cooling coil	15. Mixing section
2. Bag f1lter	9. Cooling washer	16. Supply fan
3. ES f1lter .	10. Heating coil	17. Return fan
4. Heating coil .	11. Sound absorber	
5. Activated carbon filter	12. Air vitalizer	
6. Odour neutralizer	13. Air intake	
7. Air washer	14. Sound absorber	

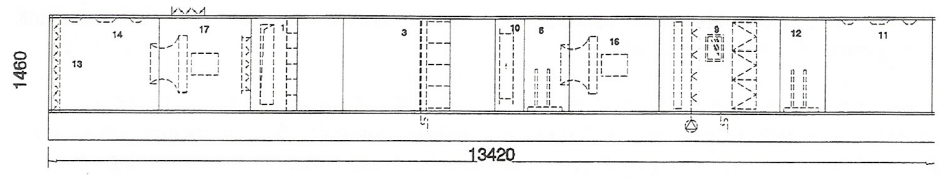

Figure 2 - Next Century AHU (Drawing Royal Verhulst Airconditioning Ltd)

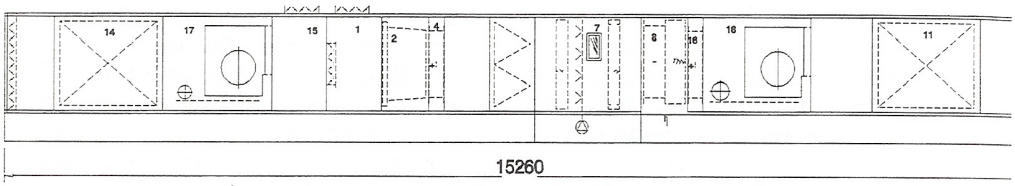

Figure 3 - Traditional AHU (Drawing Royal Verhulst Airconditoning Ltd)

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