YESTERDAY’S LUXURY, TODAY’S NECESSITY
“INDOOR AIR QUALITY” CAN NO LONGER BE NEGLECTED

W. Cheung and T. da Silva
Air Master International Limited, Hong Kong

ABSTRACT

This paper describes the design of an air-conditioning unit that incorporates a unique pulse filtration system particularly suited to address some of the problems relating to Indoor Air Quality.

The challenge facing the air-conditioning industry is to minimize the effects of poor indoor quality while maintaining low capital and operating costs. This is a formidable challenge as invariably improving the air quality requires an increase in outdoor air quantity and hence an increase in energy consumption and plant capacity.

It is shown that the proposed air-conditioning system will not necessarily increase the yearly energy cost as it makes use of a variable outdoor air volume system together with an automatic filtration system that has significantly lower maintenance costs.

1. BACKGROUND

The oil crisis of the 1970’s led to an awareness of the need to minimize energy consumption. This resulted in buildings being more air tight and in a reduction of the outdoor air component of air-conditioning plants. Guidelines were published by various institutions to advise on the minimum outdoor air values that were necessary to satisfy the occupants needs. The industry abided by the guidelines and soon ran into trouble. The 1980’s and 1990’s saw a plethora of complaints from building owners and occupants who blamed the air-conditioning systems for their allergies and sicknesses.

This in turn opened a completely new field and career opportunities for businesses and individuals in which we now call “IAQ” or Indoor Air Quality.

It has been shown that inadequate ventilation rates compounded by inappropriate building materials can indeed trigger allergies and sicknesses in people and this is well covered in the literature. However, the literature is vague on solutions to these problems and the preceding chapter describes such a solution.

2. DESCRIPTION OF PULSE FILTRATION AIR-CONDITIONING UNIT

Fig. 1 shows a typical layout of a pulse filtration air-handling unit. The unit comprises of an air mixing module a pulse filter module, an environmental module, a bacterial control module and a blower module. Each module is further described as follows.
2.1 Mixing Module

Airflow volumes, unit location and system application determine inlet sizes and locations. In particular the outdoor air quantity is proportionally controlled under the dictates of strategically located IAQ sensors such as CO₂, Radon etc., to maintain pre-set air quality standards. In addition, the system would operate on an outdoor enthalpy control cycle to further improve the indoor air quality as well as to minimize energy consumption.

2.2 Filter Module

The filter module is the innovative component of the unit. It is a single stage pulse-jet self cleaning filter concept that represents a new approach to air handling unit filtration. The low efficiency pre-filter pads usually used as the first and second stages of a three or two stage filtering system are now replaced with a single filter stage. The primary purpose of the two stages - to extend the life of the high efficiency and final filter by removing some dust from incoming air - is no longer necessary as the single stage filter can now be automatically cleaned during operation.

The pulse-jet filters have efficiencies of 93% and Arrestance efficiencies of approximately 100% based on ASHRAE Standard 52-76. It is a cylindrical and conical filter cartridge held in a horizontal position by a yoke. The yoke is attached on a vertical plate (called a tube sheet). Behind the tube sheet and centered on the outlet of each pair of cartridges is an air valve.

During normal operation, ambient air flows inward through the cartridges and into the air plenum. Up to this point, the device is operating basically as a high efficiency filter.

Each cartridge is rated at 0.283 - 0.389 m³ s⁻¹ at an initial pressure drop of 150 - 312 Pa. Hence, the total number of cartridges is controlled by this operating range.

2.3 Pressure Activated Cleaning

As the contaminants build up on the surface of the media, the pressure drop will continue to increase. When the pressure drop reaches a pre-set limit, the automatic pulse-cleaning sequence is activated. A timer/sequence activates a solenoid valve to open, releasing the pressure holding a pneumatic air valve closed. The opening of the air valve allows a blast of compressed air to leave the air manifold and proceed out through the air valve. The blast of compressed air enters the cartridge and effectively closes off the flow for a fraction of a second. The compressed air pressure wave continues down the cartridges and then radially outward, blowing the accumulated dust off the cartridges. The dusts falls into a collection tray that may be manually vacuumed or may be connected to an automatic vacuum system that will collect the dust in a centralized hopper (Fig. 2). Some of the finer particulate does re-entrain on adjacent filter cartridges. However, the tendency is for the dust to agglomerate and blow off in particulates large enough to fall down to the collection tray.

Cartridges in the top row are pulsed first, then the timer/sequence selects the next row down and the pulse-cleaning procedure is repeated. The timer/sequence continues to sequence the cleaning operation throughout the cartridges until the overall pressure drop reaches a pre-set lower limit. At that time, the cleaning process ceases until called upon again by a high pressure drop reading.

The number of elements cleaned at any instant and the time interval between are chosen so that no significant distortion of the airflow is presented.

Since the pulse-cleaning filter renews itself as needed, the old concept of how much dust a filter can hold no longer applies. The system will maintain the average pressure within its upper and lower limits virtually independently of the ambient dust concentration.

Applications in the field have shown filter life of over 4 years.

2.4 Thermal Module

The environmental module comprises of standard heat exchange systems to suit system requirements.

2.5 Bacterial Control Module

The bacterial control module comprises a bank of UV lamps to control the bacterial borne air. This module is optional to suit system requirements.

2.6 Fan Module

Fans, fan options and discharge orientations are determined by system requirements.

3. CONCLUSIONS

The pulse-filtration air-handling unit is an innovative concept to solve some of the issues relating to indoor air quality. The advantage to building owners is the reduced maintenance costs for filter cleaning. This is a significant portion of maintenance costs in countries where labour resources are relatively expensive. The narrow pressure drop maintained by the pulse system ensures a constant air supply to the space and
Fig. 2: Typical system layout
therefore a consistent outdoor air supply is also maintained. Blower horse-power savings are also optimized as a result of the constant pressure drop being maintained.

When the outdoor air supply is coupled to an enthalpy control system, then further energy savings are possible.

The system is modular in concept and therefore is easily adaptable to suit confined spaces. Heat exchange coils also remain cleaner for longer than with conventional systems and further improving thermal efficiencies.

4. **SUMMARY**

The pulse-filter air handling system is an innovative concept in the HVAC industry and offers significant benefits to building owners and occupants. It will be particularly suited in high-rise buildings with typical floor air conditioning layouts and in clean room applications. It will be possible to provide appropriate indoor air quality levels without paying a penalty on capital and operating costs.

**REFERENCES**