

Session 6 : The Mechanical Systems and Components

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AIR CONDITIONERS AND FAN-COIL UNITS

ABSTRACT

Air conditioners provide comfort and clean air to the enclosed environment and are therefore the most important means to achieve the proper indoor air quality. Equipment must be correctly designed, properly sized, with properly matched components, properly applied, correctly installed and properly maintained. If some of these actions are not carried out in a satisfying way, the equipment itself can become the source of the indoor air quality problems. It is therefore necessary to undertake an investigation of various factors able to produce these problems; research topics cover design, materials, ageing and maintenance of air conditioners and fan coil units.

1. INTRODUCTION

Using a mechanical system for ventilation or air conditioning is an obvious way to control indoor air quality. Ventilation remove pollutants from the air by dilution or using filters or air washers and, when combined with source control, is considered as the best available technique.

However, ventilation can introduce new problems which would not exist without forced air movement. Pollutants may concentrate on some places, they may propagate or redistribute increasing health hazards or simply hygiene.

The equipment itself can become the source of the indoor air quality problems. It must be correctly designed, properly sized, with properly matched components, properly applied, correctly installed and properly maintained. This list of "correct" and "proper" actions is rather long and not at all obvious. Other parameters must be also included such as operating performance, sound generation and naturally the cost of the system.

Many potential problems can be avoided applying knowledge already existing but for some of them research must be carried out in order to find a reasonable solution.

In this paper, air conditioners and fan-coil units, equipment more and more used in Europe will be considered. Only problems arising directly from this equipment will be examined as the general problems related to air conditioning systems including ductwork, filtration, humidification or heat exchangers will be considered elsewhere.

2. AIR CONDITIONERS AND FAN-COIL UNITS

2.1. Air conditioning

Air conditioning is the general term used to designate the ventilation system built in order to satisfy the comfort requirements of the occupants of a given space. It includes heating, cooling, ventilation, humidification, dehumidification and filtration.

2.2. Air conditioners

An air conditioner is a factory made encased assembly or assemblies designed as a unit to provide conditioned air to an enclosed space. It includes an electrically operated refrigeration system for cooling and possible dehumidifying the air. It may have means for heating, circulating, cleaning and humidifying the air.

When such units are intended for use in relatively small places, they are often called room air conditioners. Their capacity is then generally under 10 kW and they deliver air freely without any ducting. Much larger units are used to supply the cold air to a number of rooms through a duct system: in this case the system is very similar to full air conditioning installation.

Air conditioners are more and more used in Europe for homes, small office buildings and retail stores. The European market has been estimated at more than 700,000 units and previsions for future are very optimistic.

In the United States, 4 million small room air conditioners and 4 million larger units are installed every year.

2.3. Fan-coil Units

Fan-coil units are used for cooling and heating air with an appropriate medium, most often water. They may be of the cabinet style within a room for free air delivery or concealed within the building structure with a short ducting connected to an outlet. The principal components are:

- one or more heat exchangers,
- one or more fans with electric motors,
- condensate collecting facilities,
- air filters,
- controls,
- an appropriate enclosure.

Fan-coil units are popular and relatively cheap systems very much used in Europe. The European market has been estimated at more than a half million units installed every year.

3. PRODUCT DEVELOPMENT

In Europe, air conditioning still has a relatively bad image as a consequence of some real or supposed problems produced by such systems. However, the market has been strongly increasing in the last several years caused by several factors:

- a) better thermal comfort has been more and more required even if cooling is generally needed only during a few weeks in the summer,
- b) employees' productivity is strongly increased if the environment is controlled and the cost of air conditioning becomes more acceptable for company's management,

c) marketing and promotion by electricity producers are pushed very much in some countries in order to increase electricity consumption in summer time,

d) In theory, indoor air quality problems may be solved by air conditioning as all parameters (flow-rate, temperature, humidity, cleanliness of air) are controlled.

In the more competitive market, the manufacturers are obliged to develop better equipment. Progress has been made with more or less success on different aspects. For air conditioners and fan-coil units, the principal development concerns: efficiency, sound control and indoor air quality and comfort aspects.

To increase the efficiency, better and more efficient heat exchangers have been developed. They have to be matched correctly with fans and the combination fan-exchanger has in turn a very strong effect on sound generation. The sound is a very important parameter in selection of equipment. For some applications, the sound power is even the principal parameter used for selection (if cost is naturally not considered). The problem for designers is not easy because there are different possibilities to build this rather compact equipment.

Fan system effect is still not very well known and the development must involve important experimental checkings and verification. There is still a large possibility to improve this equipment.

For instance, we recently tested ten fan-coils of comparable size produced by ten different manufacturers. For a given cooling capacity, the sound power generated by different units were very different - up to 10 dBA difference between the most noisy and the most silent unit.

Controls are one of the important aspects under development. The users must be allowed to select proper operation of the unit in accordance with their needs. Electronics is widely used but the design becomes complicated as the unit should operate correctly and efficiently under very different conditions.

Up to now, indoor air quality aspects concerned mostly thermal comfort. Cold air should be distributed throughout the room without draught; the problem is not simple as there is a very strong influence of the environment. Other problems as dirt or odour have not been usually taken into account - normal practice is to consider that there is no problems related to the equipment.

4. ELIMINATION OF INDOOR AIR QUALITY PROBLEMS

4.1. Problems

Air conditioning may generate a number of indoor air quality problems. They concern mostly general problems of recirculation, filtration, humidification, condensation and dirt accumulation in the systems. These general problems have been considered elsewhere during this workshop; here only terminal equipment such as room air conditioners and fan-coil units will be treated.

A room air conditioner or a fan-coil unit are installed directly in the room with human occupancy and are therefore highly visible. Following problems can be easily identified:

a) excessive noise and/or vibration,

b) excessive air velocity producing draught problems,

- c) aerosol introduced in the respirable air often consisting of fibrous materials from carpets and curtains,
- d) odours, generated by the dust fixed into the equipment and often connected to stagnant water, product of condensation.

The first two of these problems are not strictly speaking related to the indoor air quality; however, it must be pointed out that the equipment should be considered as a whole and when solving one problem, it is necessary not to generate another.

4.2. Solutions

Many problems related to equipment may be solved within the present state of art. Following procedure should be used:

- a) **Design.** Elimination of product related indoor air quality problems should be included in the first stage of design together with considerations on efficiency, sound or control. Properly designed equipment will have little or not at all indoor air quality problems.
- b) **Sizing.** By correct selection of the equipment, a number of problems can be avoided. Unfortunately, the correct information is often missing. It is now generally agreed that the majority of catalogues present deformed characteristics of equipment. Claimed capacity is easily 30% higher than in reality and sound data are not at all reliable. These uncertainties are more or less taken into account by consultant engineers and system designers and selected units are therefore, often rather badly sized for given application.
European manufacturers through EUROVENT organisations are presently trying to set-up a Certification Programme for air conditioners and fan-coil units. The essential feature of this programme will be third party checking of values given in catalogues. Very active promotion of the system is in preparation and strong penalties for dishonest claims will be applied.
- c) **Component matching.** Correct selection of components include their mutual interaction which in general is not very well known. As already indicated, fan system effect may be very important and more fundamental information is needed in this field.
- d) **Application.** Design may be correct but if not applied correctly, the equipment can have a number of problems. Quality assurance system is an important tool used in order to avoid these problems. There is a general trend in the world and particularly in Europe to introduce and generalize the use of the quality assurance schemes, essentially based on the international standard ISO 9000.
- e) **Installation.** The equipment may be installed in different manners and there is often a possibility to avoid problems using a correct installation. For instance, current indoor air quality problems is generated if return air opening of fan-coil unit is placed too close to the floor: dust and fibres from carpets are easily introduced in the unit.
- f) **Maintenance.** Accessibility for inspection and maintenance should be part of design criteria. Regular changing of filters and cleaning of heat exchangers and

condensate collecting tray may avoid most of the problems. However, only in relatively large organisations the maintenance will be organised. It is therefore important to try to avoid problems without requiring a regular maintenance.

5. NEED FOR RESEARCH

Air conditioners and fan-coil units must be:

- correctly designed,
- properly sized,
- with properly matched components,
- properly applied,
- correctly installed,
- properly maintained.

If some of these actions are not carried out in a satisfactory way, the equipment itself can become the source of the indoor air quality problems.

At the present state of art, it is generally possible to satisfy a majority of above requirements. However, more fundamental research is needed in order to supply more information concerning behaviour of some important components. Following topics of research would be interesting:

Filter performance characteristics must be better defined. This include fractional efficiency (a test method should be able to determine the efficiency for each particle size), the filter performance at variable air volume conditions, influence of air leakage on filter frames, dust holding capacity and so on. Air filters are an essential component of air conditioning systems and their behaviour must be perfectly understood and known.

Adherence of dust on surfaces should be better understood in order to avoid or at least delay the accumulation of dirt in some places. A practical guideline for component design should be a final goal of such research work.

Air diffusion in a single room together with pollutant distribution including problems of stratification is still one of the essential topics where more knowledge is needed. Supply grills of air conditioners and fan-coil units should be designed in a way to insure proper air diffusion in the whole occupied zone. Unfortunately, this is done entirely in an empirical manner, clear design guidelines are still missing.

Mixing sections in some units allow supply of fresh air and in theory, insure the proper indoor air quality. Unfortunately, various dampers used for this control do not operate correctly and real conditions may be far from design values. Systematic study of dampers and air velocity distribution in mixing section would be highly appreciated; a practical guideline is needed.

Maintenance of air conditioning systems is a very important topic. The equipment must be properly maintained in order to avoid problems. It is necessary to develop a practical guideline for the maintenance of air conditioning systems. This guideline should be based on the experience of the designers and the users of air conditioning systems.

Regular cleaning of filters and cleaning of heat exchangers and