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Quality improvements with displacement ventilation

The most common complaints among users of ventilation and air conditioning equipment concern draught and particles in the air. The latter is often characterised as «dry air». Both these complaints can be eliminated or reduced significantly through displacement ventilation. Providing of course the design and installation are correct.

Gaute Flatheim

Gaute Flatheim is a director of Siv.ing. Gaute Flatheim A/S, a consultant engineering company specialising in HVAC, Energy and Climate technology with its headquarters in Stavanger, Norway. His honours B.Sc. in mechanical engineering was earned at NTH-Techical University of Norway in Trondheim.

He is a member of the Technology Committee of the Norwegian Association of Professional Engineers (NIF). He is also a member of the main committee - Health Welfare and Indoor Air - organised by NIF in conjunction with the Norwegian Medical Association and The Technical Hygiene Forum.

Gaute Flatheim

Stavanger April 9 th. 1987
NORWAY

Most ventilation and climatic installations throughout the world, are designed according to an early concept, dating from a time when draught and air quality were of less importance. With the advent of the Electric Fan, circulation ventilation became a fact in the USA, and later all over the world. Subsequently «Air Conditioning» was introduced. Its prime purpose was to regulate temperature and humidity. Primarily the early installations were in American cities where a summer climate of very high temperatures, combined with high humidity, were compensated for with a «Fresh Breeze», in areas occupied by people. Draught was an indication of «Air Conditioning», it was a necessity and a status symbol. An associated high noise level merely reinforced the impression of «quality». The basis for a climatic standard was set.

«Ventilation» as we currently interpret the term, was not essential. A «Thermal Climate» was the overriding objective. «Draughts», which today we have considerable problems with, were not then a factor.

The industry grew rapidly with an expanding market. The market became dominated by products upon which volume had made no demand for creativity or self critisism.

The industry expanded and spread its technology to all 5 continents. The technology was impressive with the development of cooling equipment, control systems, materials applications and components of every type. But everything was based on the concept we now call «Dilution Ventilation»: - the air in the room is set in motion (or recirculated) at a rate which must be high since the cooling effect is the essential factor. As is well known, this is a factor of the air velocity cubed ($q_{max} = f(V3)$). Development has been progressive for almost three generations without any revolutionary new thinking.

As HVAC engineers we often meet the argument that older buildings without ventilation and air conditioning systems are better. Solid construction with impressive ceiling heights and minimal internal heat loads result in small temperature variations both during the day and throughout the year. Technical solutions from antiquity through the centuries to the middle ages were based on fundamental physical laws. Contemporary engineering science did not constitute any problem. People followed the laws of nature and created buildings which reflected imagination and wisdom. In St. Peter's Church in Rome, in the Nidaros Cathedral in Trondheim, in the English cathedrals, in central Europe's opera houses and other monumental buildings. Simple solutions, were the engineer worked together with natural laws and succeeded. They allowed the air to be warmed under the floor and then to rise, thus displacing the room air which eventually became warm - and contaminated. The air was changed by displacement. Historically speaking, this is the way houses have been built ever since they provided a shield against the weather. The development of air conditioning would cut right across our fundamental thinking, for better or for worse.

Displacement ventilation

During the entire post-war period, concepts for air conditioning solutions have followed a pattern without major deviations throughout the world. «Improvements» are often cosmetic where all we see are major manufacturers all over the world following in each others footsteps and copying each other. As HVAC technicians, we have been too busy talking to each other and listening to each other. We have not lifted our gaze sufficiently and listened to the «real users» or customers. To those who have their workplace in buildings we have been jointly responible for «constructing». As an HVAC industry we are in an insecure position since the statistics of complaints about our products and systems are so significant. We must recreate trust - this can only be done by listening to the people who occupy the buildings we plan and design.

Since 1982, we in Norway have been working with a group known as the HTP Committee. This was appointed by The Committee of Technology in NIF. The aim of the committee is to determine the factors which link health, well-being and indoor climate. We have enjoyed excellent cooperation from doctors, toxicologists, industrial hygienists and climate technicians throughout the Nordic area. The predominant complaints are **draught and particles in the air.** The latter is often experienced as «dry air». Both of these problems may be eliminated or reduced considerably provided that correct design and installation are achieved.

Displacement ventilation can be compared to filling a bath. The water gradually rises and displaces the air above the surface of the water. Simple isn't it? In a room which has been properly designed, this will in most cases be achieved. Fresh, properly filtered air is supplied to the area occupied by our clients and is then removed at ceiling level together with the heat and contamination which, according to physical laws, rise. It is important that air is supplied at very low velocities in the areas of occupation.

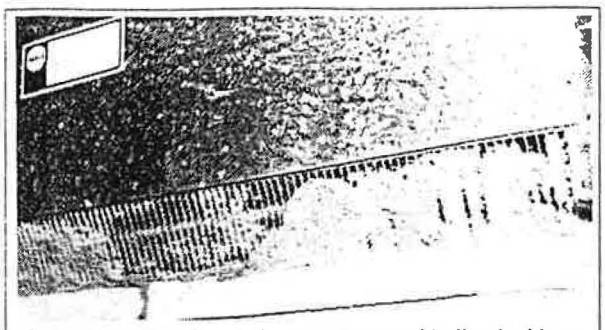
The Scandinavian who has made the greatest strides in this area is Professor P. O. Fanger. His challenge to us as HVAC technicians is to eliminate problems of draught : sensitive velocities must be reduced to below 8-10 cm/s to avoid complaints about draughts. Good design and using the right products will satisfy this challenge. It must be stressed however, that a transistion to displacement ventilation has not made life easy for HVAC technicians. The challenge has been to vastly improve on basic knowledge. We had to gain and broaden experience; expand into other engineering disciplines. The interaction between doctors, industrial hygienists, other health care staff and HVAC technicians is now an everyday necessity for our future.

Contamination - the office malady and constant companion

In recent years discussion of indoor climatic conditions has turned considerably. We are no longer concerned with just the thermal aspects of climatic control. This is because we are aware that most climatic systems fulfill the design criterea of full temperature control. We have as well, sufficient knowledge and adequate computer software/hardware enabling us to carry out calculations in an accurate and satisfactory way. However, in a circulating system, full temperature control may result in draughts. To reiterate, draughts caused by HVAC are the most predominant complaint. It is virtually impossible to avoid draughts and use a ventilation system to carry away excess heat.

To make matters worse, a number of the most common systems are based on almost 100% recirculation within the room itself. This results in a worrying concentration of fine particles in the air to be breathed. Large particles, textile fibres, man made mineral fibres and dirt of every kind settle on equipment, below windows, in induction systems.

They can also be a source of contamination which permits the growth of fungicidal spores and other bacterial growth. Most of the smallest and most dangerous particles pass through the heating and cooling coils and into the room in a continuous recirculation process. The number can be very high. In newer office buildings, 100 milliom particles per m^3 room air have been measured - some of submicroscopic size.



Induction unit under window in a 3 years old office building. A lot of contaminations on the heating coil.

There are few statistics available in this area. If however these numbers are representative for offices with carpeted floors and induction units, then there is an obvious need for closer analysis of sickness, absence, dissatisfaction and discomfort. This must then be compared with office buildings where displacement ventilation has achieved a drastic reduction of the particle content in the breathing zone. This is particularly important since medical people consider that fine dust transports «Stowaways». Bacteria are spread very efficiently through the ventilation ducts on the backs of dust particles. They enter airways and cause throat infections and perhaps some lung complaints. Some of the particles are deposited in our alveoli according to Dr. Med. Kjell Aas, a specialist and head of «Voksentoppen», (The institute for children with asthma and allergies). Fine dust is perhaps the most significant reason why the displacement principle has gained such popularity among our clients.

The other side of the coin

«Energy Conservation» has become very popular. We must however beware of the side effects. Economy taken in the wake of the oil embargo of 1974 effectively resulted in a reduction of the supply of air in buildings. This is an example of how economy measures can have a detrimental effect on the indoor climate or environment. It has resulted in headaches, nausea and other discomforts.

We have now become more aware of the negative side effects of recirculatory systems. The transportation or movement of fresh air must be upgraded to satisfy hygiene requirements. We can no longer be satisfied with stale air being circulated at random through fresh air ducts. It results in contamination from many sources. The contaminated air from many different areas and rooms is deposited into the supply system and redistributed to the users.

An alternative is the use of plate type waste heat recovery systems or recovery systems using glycol - both are designed for separated duct systems. The recirculation principle should, quite simply, not be used; neither in the form of a «bypass valve» nor in any other way. A far less dangerous economy measure is displacement ventilation itself. SINTEF in Trondheim has shown that displacement ventilation in addition to providing a better office environment, allows for the reduction of fresh air quantities, through its- «Ventilation systems' efficiency project». When fresh air is supplied in the vicinity of the user, he will at all times be supplied with air having a higher level of purity than in parts of room above the area of occupation. This means that we can reduce the quantity of air by 20% in comparison with circulation.

Rehabilitation

In cooperation with A/S Norsk Viftefabrikk we have developed a Displacement Air Diffuser. This has been specially designed to replace conventional Supply Air Ventilators in office buildings. Currently nine of these devices have been installed in a newish building and so far the results have proved satisfactory. The primary air quality of approximately 70 m^3/h per module has been retained and is supplied at a velocity 7-8 cm/s in the area of occupation. There is no secondary air and heat is supplied by thermostatically controlled electrical heaters. These are installed in positions, which ensure they provide the least possible undesirable convection flow, in the vicinity of the fresh air supply

The diffuser device is undergoing further development. It may well be possible to produce versions which will be compatible with existing primary and secondary systems in the same building.

This particular building has a central cooling system. Because of this we must retain the heat source (e.g. wall heaters) to prevent the rooms being supplied with fresh air at too low a temperature.

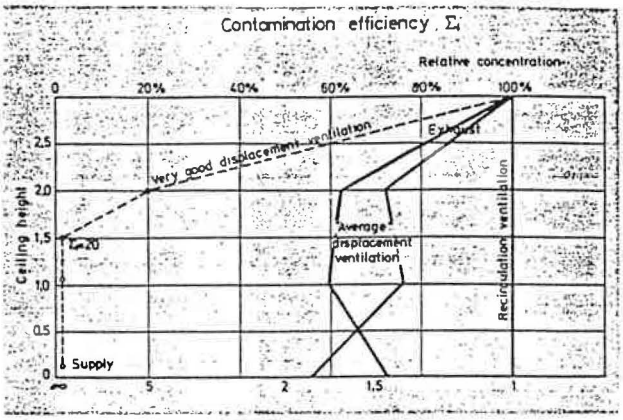
In buildings with secondary cooling, for example four duct supply air systems, it is natural to install cooling ceilings for the cold water circuit. Thus the displacement air diffuser may be used without additional heating. This could be a DIFF-DON (differential air diffuser) as shown in figure 2.

The Diff device place in a wall, in the «square» to the right of the door.

An insurace building constructed in the 1880s has been completely renovated. Surplus heat is directed to a cooling ceiling. Draught-free, filtered fresh air is supplied at low level in the area of occupation through a device by the side of a door to a corridor. The system works very well.

Recommendations

Displacement ventilation provides considerably better quality air than circulatory systems. In some cases, the air in the breathing zone may be up 20 times better than that provided by recirculation. This varies considerably as shown in SINTEF's graph in figure 3.



«Avarage Displacement Ventilation» is worth underlining, as it does after all provide an efficiency improvement of up to 50%. For the future, it is absolutely necessary to work in an environment that has the least recirculation, consequently the least number of particles in our breathing air.

A good indoor climate is also dependant on other factors, carpeting for example. There is need for a critical analysis of carpets. Carpet fibres are a serious source of unease to us. Some types function as effective dust collectors and a favourable environment for undersirable bacteria. Some types of carpet are also a cause of static electricity, since they are almost non-conductive. We must prevent the situation where the contract of fresh air streams and mineral insulating wool causes the release of particles into the atmosphere. So preventing their ingestion into lungs and airways.

In our consulting group, we intend building up expertise. We will be spreading information on all conditions which effect the indoor climate of office buildings, schools, light industry and housing.