Environmental Air Conditioned Requirements New Approach

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Abstract: There are different ways in air conditioned characteristics selection and approach, following the specific application (domestic, office, industrial or technological. For each practical situation, there are designed special parameters, defined on the application necessities, climate conditions, field dimensions, temperature required, thermal losses etc. In domestic application, field studies demonstrate that there are substantial numbers of not-satisfied people in many buildings, among them those suffering from Sick Building Syndrome symptoms, even there are established special standards and guidelines to comply. Based on existing information and on new research results, five principles are suggested as elements behind a new philosophy of excellence: better indoor air quality increases productivity and decreases Sick Building Syndrome (SBS) symptoms; unnecessary indoor pollution sources should be avoided; the air should be served cool and dry to the occupants; "personalized air", i.e. a small amount of clean air, should be served gently, close to the breathing zone of each individual.
Key-Words: Air conditioning, Comfort, Air quality, Productivity, Health, Sick building.

1 Introduction

Air-conditioning of buildings has been essential for economic development in areas with warm climates or warm summers. Over the last 40 years, these areas have experienced a remarkably strong economic growth rate which would hardly have been possible without the widespread use of air-conditioning.

Today air-conditioning is used in many parts of the world, often in combination with heating and ventilation in HVAC systems. The image of such systems, however, is not always positive. The purpose of most systems is to provide thermal comfort and an acceptable indoor air quality for human occupants. But numerous studies [2] have documented substantial rates of dissatisfaction with the indoor environment in many buildings. One of the main reasons is that the requirements of existing ventilation standards and guidelines [2] are quite low. The philosophy of these documents has been to establish an indoor air quality where less than a certain percentage (e.g. 15, 20 or 30%) of people is dissatisfied by the indoor air quality, while the rest may find the air barely acceptable. A similar thinking refers to the thermal environment [8]. This philosophy behind the design of HVAC systems has led in practice to quite a number of dissatisfied persons (as predicted), while few seem to be ready to characterize the indoor environment as outstanding. At the same time numerous negative effects on human health are reported: many persons suffer from SBS symptoms [2] and dramatic increases in cases of allergy and asthma have been related to poor indoor air quality (IAQ).

It is fair to say that the indoor air quality is quite mediocre in many air-conditioned or mechanically ventilated buildings, even though existing standards may be met. It is necessry a paradigm shift in the new century to search for excellence in the indoor environment. The aim of the systems should be to provide indoor air that is perceived as fresh, pleasant and stimulating, with no negative effects on health, and a thermal environment perceived as comfortable by almost all occupants. In achieving this aim, due consideration must be given to energy efficiency and sustainability. On thermal comfort it is available a comprehensive database, while the knowledge on indoor air quality is still rather incomplete. This reflects the complexity of the interaction between indoor air quality and human comfort and health. But important new research results that will have a significant impact on the design of future ventilated spaces for human occupants.

2 Indoor atmosphere quality environmental impact on human activity

New research results document that the quality of indoor atmosphere has significant influence on the human activity [2]. Beside the temperature influence, the ventilation and climate devices have impact on the potential pollution source, invisible to the occupants. The two cases corresponded to a low-polluting and a non-low-polluting building as specified in the new European guidelines for the design of indoor environments [2]. The same subjects worked for 4.5 hours on simulated work in each of the two air qualities. The ventilation rate and all other environmental factors were the same under the two conditions. The productivity of the subjects was found to be 6.5% higher ($P<0.003$) in good air quality and they also made fewer errors and experienced fewer SBS symptoms [1]. This study performed in Romania has since been repeated in Moldova with similar results. The results from these blind studies show that improved air quality increases productivity significantly. This increase should be compared with the cost of conditioning the indoor environment, which for buildings in the developed countries is typically less than 1% of the labor cost. There is, therefore, a strong economic incentive to improve the indoor air quality. On the basis of a literature survey [2], estimated the economic losses caused by poor IAQ due to illness, absenteeism and lost production in the EU [1].The conclusion in both cases is that the estimated losses are high compared to the cost of running the HVAC systems. While information on the negative impact of poor IAQ on productivity is new, there is more data available on the negative influence of warm discomfort on productivity. It has given an excellent review of the literature on thermal discomfort and productivity [12].

3 Pollution source control

Avoiding unnecessary indoor air pollution sources is the most obvious way to improve indoor air quality. Its effect on productivity and SBS symptoms has been demonstrated in the study discussed above [9].
Source control has also been used with great success outdoors and is the reason why the outdoor air quality in many cities in the developed world is much better today than it was 20 or 60 years ago. In the new European guidelines for the indoor environment [6], there is strong encouragement to design low-polluting buildings and recommendations on low-polluting building materials are given. Systematic selection of materials to avoid the well-known cases of SBS caused by polluting materials is common practice in several countries. Pollution sources in the HVAC system are a serious fault, degrading the quality of the air even before it is supplied to the conditioned space [2]. Source control is the obvious way to provide good indoor air quality with a simultaneous decrease in the consumption of energy. But increased ventilation also improves the indoor air quality and decreases SBS symptoms as demonstrated by classic studies [2] (fig.1). The energy cost of increased ventilation may be minimized by efficient heat recovery.

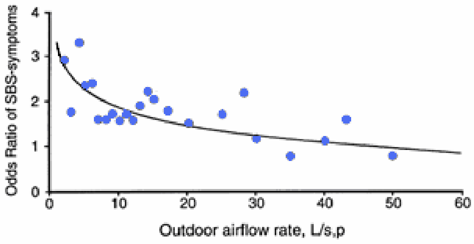

Fig.1: The risk of Sick Building Syndrome (SBS) symptoms as a function of ventilation rate in 60 once buildings in Romania [14].

4 Air provided quality control

Air humidity. In ventilation standards, indoor air humidity has for decades been overlooked. It has been generally accepted that the relative humidity was rather unimportant for human beings as long as it was kept between approximately 30 and 70% [5-7]. This consensus stems from the fact that the humidity in the comfort range of temperatures has a minor impact on the thermal sensation of the entire human body [2] The implied conclusion is that the required ventilation is independent of temperature and humidity. However, indicated in 1991 that temperature and humidity have an impact on the perception of clean air in a climate chamber [2].
Air temperature. New studies have demonstrated that perceived air quality is strongly influenced by the humidity and temperature of the air we inhale. People prefer rather dry and cool air. The strong effect of humidity and temperature on perceived air quality was proven in experiments where 36 subjects judged the acceptability of air polluted by different typical building materials in a climate chamber [18]. It is the effect of humidity and temperature combined in the enthalpy of the air that is essential for the perceived air quality as shown in Fig. 2.

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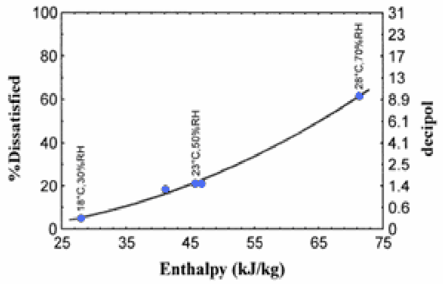

Fig. 2: Perception of clean air during whole-body exposure of persons to different levels of indoor air enthalpy [18].

The thermal sensation for the entire body was kept neutral (neither too warm nor too cool) by modification of the subjects' clothing. The acceptability did not change with time, i.e. no adaptation took place. The impact of enthalpy on acceptability or on perceived air quality expressed in percentage dissatisfied is strong. Two other independent studies where approximately 60 subjects were exposed to numerous combinations of humidity and temperature on the face also showed an excellent correlation between enthalpy and acceptability [2]with an even stronger impact of enthalpy. Humans obviously like a sensation of cooling of the respiratory tract each time air is inhaled. This causes a sensation of freshness which is felt pleasant. If proper cooling does not occur, the air may feel stale, study and unacceptable. A high enthalpy means a low cooling power of the inhaled air and, therefore, an insufficient convective and evaporative cooling of the wet mucous membranes in the respiratory tract, and in particular the nose. This lack of proper cooling is closely related to poorly perceived air quality.

This is presumably why humidity has previously been overlooked. The new studies show that the local effect of air temperature and humidity on the respiratory tract and, therefore, on perceived air quality is one order of magnitude higher than for whole body thermal sensations. This new evidence has quite dramatic practical consequences. It is obvious that the enthalpy has a strong impact on ventilation requirements and therefore on energy consumption. Showed thus in their most recent study that people perceive the indoor air quality better at 20 ^{0}C and 40% RH and a small ventilation rate of 3.5 l/s/person than at 23 0C and 50% RH at a ventilation rate of 10 l/s/person [2]. It is advantageous to maintain a moderately low humidity and a temperature that is at the lower end of the range required for thermal neutrality for the body as a whole. This will improve the perceived air quality and decrease the required ventilation. It is surprising to note that even in warm and humid climates it may save energy to maintain a moderate indoor air temperature and humidity. Of course it requires more energy per m^3 to cool and dehumidify the outdoor air further, but this will be compensated for by fewer m^3 of outdoor air required for ventilation. Field studies [2] show that moderate air temperatures and humidity also decrease SBS symptoms. There are, therefore, several good reasons to follow this advice: serve the air cool and dry for people.

5 Air quality at the consumer

In many ventilated rooms the outdoor air supplied is of the order of magnitude of 10 l/s/person. Of this air, only 0.1 l/s/person, or 1%, is inhaled. The rest, i.e. 99% of the supplied air, is not used. What a huge waste and the 1% of the ventilation air being inhaled by human occupants is not even clean. It is polluted in the space by bio-effluents, emissions from building materials and sometimes even by environmental tobacco smoke before it is inhaled. In the future could be provided systems that supply rather small quantities of clean air close to the breathing zone of each individual. Obviously, it is preferable to serve small quantities of high-quality air direct to each individual rather than serving plenty of mediocre air throughout the space. Such "personalized air" (PA) should be provided so that the person inhales clean, cool and dry air from the core of the jet where the air is unmixed with polluted room air (Fig.3).

The PA may come from an outlet next to the PC on the desk (Fig.4). It is essential that the air is served "gently", i.e. has a low velocity and turbulence which do not cause draught [2]. Please note that personalized air has nothing to do with individual thermal control for the entire body, which should be provided by other means (see below).

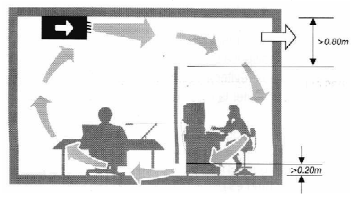

Fig. 3: The principle of personalized air (PA)

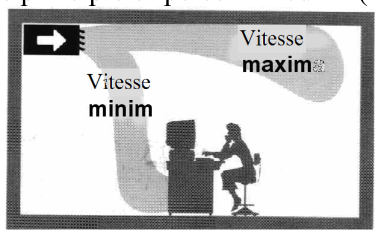

Fig. 5: Example of PA supplied workstation

6 Individual thermal control

In buildings where many people occupy the same space it is difficult to provide thermal comfort for everyone at the same time. The traditional way of handling this is to aim for a compromise at an "optimal temperature" where as few persons as possible are dissatisfied [1].
In a space with traditional mixing of the ventilation air, it is beneficial that the air be kept at a moderately low temperature, corresponding to the coolest temperature preferred by any of the occupants. In a once this may for instance be 20 or 21^0C to provide appropriate cool inhaled air. It is essential that these small heating flows be provided by radiation or conduction, so that the air is still kept cool and pleasant to inhale. Individual thermal control by air movement should be avoided due to the risk of draught [2].

Table 1

Flow access position	Velocity
Over the access entrance	4,5 /s
On the access entrance and over the chair	3,5 to 4,5 m/s
On the access entrance and near the chair	2,5 to 3,5 m/s
Over the door	1,5 to 2 m/s
Below the door	1 to 1,5 m/s

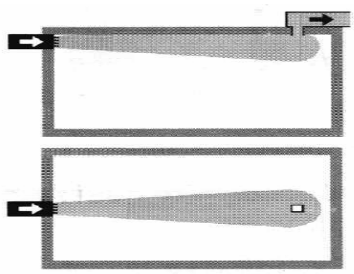

Fig. 5: Evacuation placement examples

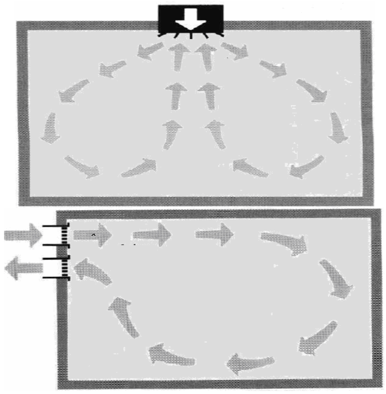

Fig. 6 Evacuation placement examples

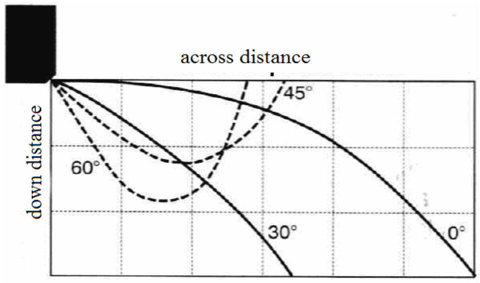

Fig. 7 illustrates for a particular clime device the jet rejections for different air flow angles in “heating and refresh” mode.

7 Conclusions

The following principles may be useful steps in realizing such a new philosophy of excellence.
- Better air quality pays as it results in higher productivity and causes fewer Sick Building Syndrome symptoms.
- The air should be served cool and dry for people.
- Small amounts of clean air should be served where it is consumed, i.e. as "personalized air" close to the breathing zone of each person
- Unnecessary pollution sources should be avoided.
- Individual thermal control should be established to handle personal differences in thermal preference.

The above principles of excellence are compatible with energy efficiency and sustainability.
The indoor environment in many buildings existing today is rather mediocre and gives rise to frequent complaints, even though present standards are met. - Better air quality pays as it results in higher productivity and causes fewer Sick Building Syndrome symptoms.
- The air should be served cool and dry for people.
- Small amounts of clean air should be served where it is consumed, i.e. as "personalized air" close to the breathing zone of each person
- Unnecessary pollution sources should be avoided.
- Individual thermal control should be established to handle personal differences in thermal preference.

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