EFFECT OF A NEEDLE HEAT EXCHANGER ON THE RELEASE OF MICROBES INTO SUPPLY AIR

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ABSTRACT

The needle heat exchanger (acts as a pre filter EU3) was installed in front of the glass fiber used as a fine filter (EU7) in the supply air chamber. Thus, the temperature of the supply air increased and the relative humidity of the fine filter next to the heating unit decreased. The aim of this study was to examine how the installation of the needle heat exchanger effects on the microbial growth and release in the fine filter. The relative humidity of the fine filter in the supply air unit fell below 70 % during different seasons. Reduced relative humidity seemed to reduce the contamination or at least the release of microbes from the fine filter. However, an interesting observation was the presence of the thermophilic microbe *Aspergillus fumigatus* in the material sample taken from the glass fiber filter, in air of cold supply air chamber and on surfaces of the heat exchanger and warm air chambers, but not in the supply air.

KEYWORDS

Microbes, supply air, filtration, heating, humidity conditions

INTRODUCTION

Ventilation system is designed to improve indoor air quality, but it has been found out that it may cause deterioration of indoor air (Halonen *et al*. 1999, Halonen *et al.* 2000a). Moisture problems of supply air device are considered to be common, but the extent of the problem has not been widely studied. Lysne *et al.* (1999) found moisture problems in about 50 % of the supply air devices. Microbes remain viable on filter materials even at low temperatures, if the relative humidity is high enough (Halonen *et al.* 2000b). The aim of this study was to examine how the installation of the needle heat exchanger effects the microbial growth and release in the fine filter.

MATERIALS AND METHODS

The needle heat exchanger was installed in front of the glass fiber filter (EU7) in the supply air chamber (figures 1 and 2). It acts as a pre-filter EU3 and a pre-heater of supply air. In addition, the needle heat exchanger does not need any pre-filter and it can be maintained by washing with water.

The temperature and relative humidity were monitored continuously during winter, summer and autumn (Vaisala HMP 143 A and Vaisala HMP 230) and data taker (Grant SQ 1027).

Culturable microbes were determined from the samples to evaluate the microbial contamination. Mesophilic fungi were cultivated on Rose Bengal malt agar (Hagem agar), 2 % malt extract agar (MEA) and dichloran glycerol agar (DG18), bacteria on tryptone yeast glucose agar (TYG) for 7 days at +25 ^{o}C, and thermophilic fungi on MEA for 5 days at +40^{o}C. Results are expressed as indicated in parentheses for each sample type. The samples were taken from fine filter material (cfu/g, cfu = colony forming units), air (cfu/m^{3}) and surfaces (cfu/plate) from supply air chamber in cold and warm section.

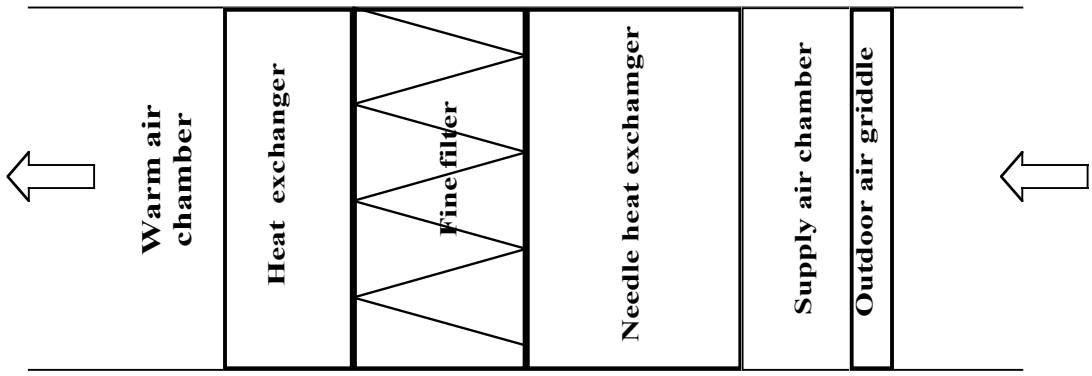

Figure 1: A supply air unit with a needle heat exchanger.

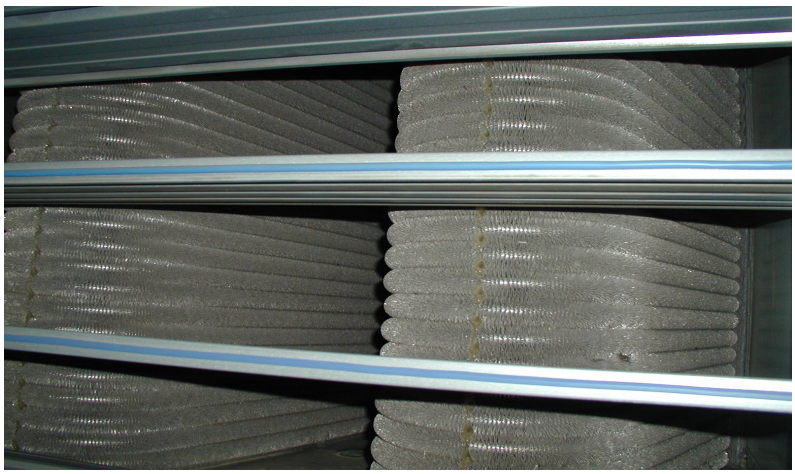

Figure 2: A needle heat exchanger seen from a supply air chamber.

RESULTS

Relative humidity and temperature

Averages of relative humidity in the fine filter fell below 70 % in winter (40 %), in summer (58 %) and in autumn (65.5%). Thus, the humidity conditions did not favor microbial growth. The temperature in the fine filter bag exceeded 8 °C (winter, +8.7°C; summer +17.1°C; autumn +16.2°C) which was enough for the growth of microbes. (Table 1.)

TABLE 1
The temperature (T, ^{o}C) and relative humidity (RH, %) was followed continuously in outdoor air, in filter bag air and in indoor air during winter, summer and autumn. Water content (w, g/m^3) is calculated from RH - and T-values. $_o$=outdoor, $_f$=filter and $_i$=indoor

Season	Relative humidity (%)			Temperature (^{o}C)			Water content (g/m^3)
	outdoor	filter	indoor	outdoor	filter	indoor	
Winter	95	40	22	3.9	8.7	17.8	3.5
Summer	68	58	51	15.5	17.1	19.1	8.6
Autumn	77.1	65.5	57.0	14.6	16.2	18.1	9.6_o;9.1_f;8.8_i

Microbes

Winter

Low concentrations (below 10 cfu/m^3) of *Aspergillus versicolor** (moisture indicating microbe = *) were detected only in wintertime in warm supply air chamber both before and during turning the fan operation on. At the same time outdoor air included low concentrations (below 100 cfu/m^3) of *Aspergillus, Cladosporium, Geotrichum* and *Penicillium*. (Table 2.) The material sample of fine filter included high concentrations (10^3- 10^5 cfu/g) of *Aureobasidium*, Penicillium* and sterile fungi. (Table 4.)

TABLE 2
The occurrence of different microbes in winter in air, surface and material samples in the supply air system equipped with the needle heat exchanger.
(+= microbe was detected, -=microbes was not detected).

Microbe	Air in cold air chamber or outdoor air	Air in warm air chamber	Surface of filter chamber	Fine filter material
Aspergillus spp.	+	-	-	-
*Aspergillus versicolor**	-	+	-	-
*Aureobasidium **	-	-	+	+
Cladosporium	+	-	-	-
*Engyodontium**	-	+	-	-
Geotrichum	+		-	-
Penicillium spp.	+	+	+	+
Sterile fungi	+	-	-	+
Yeasts	-	-	+	-

(* = microbe thriving on moist environmental conditions)

The greatest variety of microorganisms was found in cold air chamber. Surface samples and fine filter material showed high similarity of microflora. *Aspergillus versicolor* and *Engyodontium* were found only in air samples taken in warm air chamber.

Summer

Moderate concentrations (about 300 cfu/m^3 in total) of various species of microbes like *Aspergillus fumigatus*, Aureobasidium*,* basidiomycetes*, *Cladosporium, Geotrichum, Penicillium, Thysanophora, Trichoderma*, Tritirachium*, Verticicladium*, sterile fungi and yeast were detected in outdoor air during summer (Table 3). However, low concentrations (below 10 cfu/m^3) of *Aureobasidium*, Cladosporium* and *Penicillium* only were found in the warm air chamber after the heating unit and the fine filter.

TABLE 3
The occurrence of different microbes in summer in air, surface and material samples in the supply air system equipped with the needle heat exchanger.
(+= microbe was detected, -=microbes was not detected).

Microbe	Air in cold air chamber or outdoor air	Air in warm air chamber	Surface (**=surface of filter chamber)	Fine filter material (Ns=no samples)
*Acremonium**	-	-	+**	Ns
Alternaria	-	-	+	Ns
Aspergillus spp.	-	-	+	Ns
*Aspergillus fumigatus**	+	-	+	Ns
Aspergillus niger	-	-	+	Ns
*Aureobasidium**	+	+	+**	Ns
Basidiomycetes*	+	-	-	Ns
Cladosporium	+	+	+**	Ns
*Eurotium**	-	-	+	Ns
Geotrichum	+	-	-	Ns
*Mucor**	-	-	+	Ns
Penicillium spp.	+	+	+**	Ns
Sphaeropsidales*	-	-	+	Ns
Sterile fungi	+	-	+**	Ns
Thysanophora	+	-	-	Ns
*Trichoderma**	+	-	-	Ns
*Tritirachium**	+	-	-	Ns
Verticicladium	+	-	+	Ns
Yeasts	+	-	+**	Ns

(* = microbe thriving on moist environmental conditions)

Greatest variety of microorganisms was found in samples taken in summer. Air samples taken in warm air chamber was the only exception having only three same taxa as in outdoor air sample.

Autumn

High concentrations (below 2000 cfu/m^3) of *Acremonium, Alternaria,* basidiomycetes, *Cladosporium, Geotrichum, Penicillium, Tritirachium,* sterile fungi and yeast were detected in outdoor air during autumn. The sample swept from the chamber floor included moderate levels of various microbes like *Aureobasidium, Alternaria, Cladosporium, Mucor, Penicillium, Verticicladium,* sterile fungi and yeast (Table 4). In addition, the material sample of the fine filter included *Aspergillus fumigatus, Aureobasidium, Cladosporium, Penicillium*

and sterile fungi (10^4-$26.5x10^4$ cfu/g). However, only low concentrations (below 10 cfu/m^3) of *Cladosporium* and *Polyscytalum* were found in the warm air chamber.

TABLE 4
The occurrence of different microbes in autumn in air, surface and material samples in the supply air system equipped with the needle heat exchanger.
(+= microbe was detected, -=microbes was not detected).

Microbe	Air in cold air chamber or outdoor air	Air in warm air chamber	surface	Fine filter material
*Acremonium**	+	-	-	-
Alternaria	+	-	+	-
*Aspergillus fumigatus**	-	-	-	+
*Aureobasidium**	-	-	+	+
Basidiomycetes*	+	-	-	-
Cladosporium	+	+	+	+
Geotrichum	+	-	-	-
*Mucor**	-	-	+	-
Penicillium spp.	+	-	+	+
Polyscytalum	-	+	-	-
Sterile fungi	+	-	+	+
*Tritirachium**	+	-	-	-
Verticicladium	-	-	+	-
Yeasts	+	-	+	-

(* = microbe thriving on moist environmental conditions)

An interesting observation was the presence of the thermophilic microbe *Aspergillus fumigatus* in air of cold supply air chamber (summer, table 3) and on surfaces of the heat exchanger and warm air chambers (summer, table 3) and in the material sample of the filter (autumn, table 4), but not in the warm supply air. However, the filtration units generally seemed to prevent effectively the release of microbes into warm supply air.

DISCUSSION

In our earlier studies (Halonen et al., 1999 and Halonen et al., 2000a) we have found that filtration with a fine-filter unit only is not effective to prevent microbial growth e.g. *Aureobasidium* and *Aspergillus fumigatus* or transport through ventilation system. In addition, the filtration with a fine-filter only was not found to end building related complaints, although the air conditioning systems were cleaned and adjusted (Halonen et al., 2000a). Either the entry of rain was prevented totally by the designed storm grille or with the pre-filter and the temperature and humidity conditions observed in two air conditioning units were potentially favorable for microbial growth even during cold winter time (Halonen et al., 2000b). In addition, the periodical operation of ventilation system with turning off during nights and weekends seemed to create more favorable conditions for survival of microbes in the infiltration filter than the continuous operation did (Kokotti et al., 2002).

CONCLUSIONS

Despite of sufficient temperature conditions, the decreasing effect of the heating unit on relative humidity of the fine filter generally seemed to reduce the contamination or at least the release of microbes from the fine filter. However, the thermophilic microbe *Aspergillus fumigatus* was analyzed in air of cold supply air chamber, in the material sample of the filter and on surfaces of the heat exchanger and warm air chambers, but not in the warm supply air.

ACKNOWLEDGEMENTS

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