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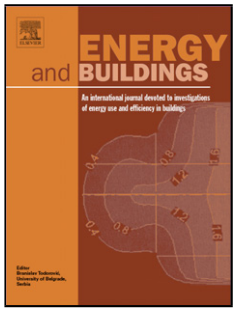

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Particulate fouling assessment in membrane based air-to-air energy exchangers

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ABSTRACT

The impact of air-side particulate fouling on the performance of membrane-based, fixed-plate energy recovery ventilators (ERVs) is investigated for both fine and coarse (0.3-10µm) as well as ultrafine (~ 0.1µm) aerosols. Two residential size cross-flow ERV exchanger cores were fouled with ISO A3 medium test dust. It was found that coarse dust loading, equivalent to that of a few years of exposure in a heavily polluted environment, has minimal impact on the performance of ERV exchanger cores. In both cases, the sensible and latent effectiveness were actually slightly enhanced due to boundary layer thinning and additional turbulence potentially caused by the dust layer. Heavy dust loadings, in the absence of appropriate filtration upstream, may result in a fan energy penalty (~50%) due to the added pressure drop across the exchanger cores.

Samples of three different membrane transport media, extracted from commercial HVAC ERV exchanger cores, were loaded with graphite and NaCl aerosol nanoparticles. Accelerated loading experiments were conducted in a laboratory apparatus to simulate several years of fouling in the field. Initial and post-loading water vapor permeance through the membrane samples were experimentally determined for each loading to quantify the effects of fouling. The impact of relative humidity on the performance of loaded membranes was also studied by exposing membranes loaded with particles in dry air to an elevated RH of 75%, leading to surface condensation. The experiments show that the deposition of particles in dry air can only affect the membrane when the fouling is severe enough to form a cake layer on the membrane surface comparable to the thickness of the membrane. In the case of membranes loaded with hygroscopic salt particles, surface condensation at high RH values can lead to vapor permeance reductions of up to 15% well before the cake layer formation phase of fouling, whilst no permeance reduction was observed for membranes loaded with non-hygroscopic graphite particles. This indicates a net porosity reduction in the microporous substrate layer of exposed salt-loaded samples. A pore-narrowing process of the substrate layer, due to the mobilization of salt particles in aqueous form, is a potential explanation for these observations.

Keywords: Particulate fouling; nanoparticles; energy recovery ventilator; enthalpy exchanger; polymer membrane

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