Experimental Studies of the Effect of Rough Surfaces and Air Speed on Aerosol Deposition in a Test Chamber

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Understanding the fate of particles indoors is important for human health assessment because deposited particles, unless re-suspended, cannot be inhaled. To complement studies in real buildings, where control of variables is often difficult, an experimental test chamber facility (8 m³) was designed to study particle deposition under well-stirred conditions using monodisperse tracer aerosol particles in the range of 0.7 to 5.4 μm. The use of neutron-activatable tracers facilitated simultaneous surface sampling and aerosol concentration decay measurements.

Aerosol deposition on both smooth surfaces and regular arrays of three-dimensional roughness elements under 3 different airflow speeds was investigated in the test chamber. It was expected that the texture of the chamber surface would significantly influence particle deposition, but some counterintuitive results were observed: under the lowest airflow condition and for the smallest particle size, particle deposition onto rough samples was found to be less than on the corresponding smooth surfaces.

The ratio of particle deposition on rough surfaces relative to smooth surfaces increased with particle size and magnitude of airflow. For the largest particle size and airflow speed, particle deposition on the rough surfaces exceeded that on the smooth surfaces by a factor of 3.

INTRODUCTION

The acute effects of inhaled ambient particles on the health of the general public, including mortality, hospital admissions, respiratory symptoms, and lung function, have been extensively studied and supported by epidemiological studies (i.e., Pope et al. 1995; Anderson et al. 1996). It is well known that developed populations spend significant periods indoors, and the increased interest in indoor air quality studies (Wallace 1996) in recent years reflects a concern that indoor air quality is of equal or greater importance than outdoor air quality to human well being.

When the overall air exchange rate between indoors and outdoors is low, the probability of inhalation exposure reduction to outdoor air pollution by the occurrence of aerosol deposition on indoor surfaces may be significant (Nazaroff and Cass 1989). Cold climates cause building inhabitants to close windows and doors, leading to low overall building infiltration rates. However, while providing protection against inhalation exposure to outdoor pollutants, low air exchange rates adversely increase the inhalation probability of indoor-generated particle sources associated, for example, with cooking and smoking (Lai et al. 2001b). In the context of specific atmospheric contamination episodes, however, the net benefits in terms of overall exposure reduction may be significant. Fogh et al. (1997), by considering the effect of indoor aerosol deposition, have shown that the benefits, in terms of reduction in inhalation exposure following a nuclear accident, achieved by staying indoors with the windows closed may be as high as 80%.

Current descriptions of particle deposition indoors are far from complete; imprecise modeling parameters exist, due to a lack of comprehensive indoor aerosol deposition data, and existing model formulations, based on the seminal work of Corner and Pendlebury (1951), lack a thorough physical foundation. Recently, Lai and Nazaroff (2000) proposed a model with a stronger physical foundation, which helps account for a previously unexplained experimental observation regarding the functional dependence of deposition on particle size. However, this model only predicts deposition onto smooth surfaces. In practice, most indoor surfaces are “rough” in terms of particle deposition (Lai et al. 2001a); vertical surfaces covered by paints or wallpaper, for example, may have protrusions that are of the order of millimeters. As the particle concentration boundary layer is very...
thin, a very small distortion of flow structure close to a protrusion may greatly affect deposition rate.

Aerosol decay rate measurements have been made by a number of researchers, notably Harrison (1979), who used a 0.2 m$^3$ cubic plywood box with both rough (latex paint) and smooth (aluminum foil) interior surfaces under a natural convective flow. Except for the smallest particle size studied (0.2 μm), no difference was observed between the particle decay rate constant for the rough- and smooth-walled box.

Further aerosol decay rate measurements were carried out by Shimada et al. (1987), who measured monodisperse particle decay rates in a small Perspex tank (0.002 m$^3$) with different grades of sandpaper covering the inner surface of the tank. Experiments were conducted over a range of fan-generated airflow speeds, and the aerosol decay rate constant was found to increase with increasing roughness scale for a fixed speed. To account for their experimental observations, Shimada et al. (1987) proposed a semiempirical model in which they defined a “particle-free region” where no particles existed statistically. They did not, however, evaluate the thickness of this layer directly.

A small number of test chamber studies have simultaneously quantified the particle flux onto surfaces and particle concentration decay rate. Byrne et al. (1995) employed a neutron-activatable monodisperse tracer aerosol to measure deposition velocity onto a smooth vertical wall of an 8 m$^3$ aluminum chamber under a single well-stirred flow condition. Thatcher and Nazaroff (1997) used monodisperse fluorescent tracer particles to measure deposition velocity under natural convective conditions to irregular rough surfaces in a 1.8 m$^3$ aluminum chamber. Abadie et al. (2001) studied experimentally the rate loss coefficient for several wall textures in a small cubic chamber (0.216 m$^3$). Three different particle sizes (0.7, 1, and 5.0 μm) were injected into a box mechanically stirred by a fan. Only the decay of particles was directly monitored, so the deposition on the walls was inferred indirectly from the measurements.

A review of previous research indicates that there are only a small number of studies (e.g., Shimada et al. 1987; Nomura et al. 1997; Thatcher et al. 2001) of the effect of airflow parameters on aerosol decay or deposition in room-sized enclosures, and none of these address the direct measurement of aerosol deposition on small-scale roughness elements of the dimensions commonly found in wall-coverings (studies such as that of Fogh et al. (1997) have compared aerosol decay deposition velocities in fully-furnished and unfurnished rooms). To address this, in the present work aerosol decay rates were determined for 4 particle sizes in a smooth-walled 8 m$^3$ test chamber, at a different fan speed to that studied by Byrne et al. (1995) in the same chamber, so that the effect of fan speed on a size-specific deposition rate could be observed. In addition, aerosol deposition on a regular array of three-dimensional roughness elements was determined in the 8 m$^3$ test chamber under three different well-stirred airflow conditions for a single particle size. Following this, the relative deposition of 4 particle sizes on smooth and rough surfaces was determined for a single airflow speed.

EXPERIMENTAL SETUP AND SAMPLE ARRANGEMENT

Particle Generation and Aerosol Test Chamber

Four different sizes of monodisperse tracer labeled particles were prepared for this work, with mass median aerodynamic diameters of 0.7 μm, 2.5 μm, 4.5 μm, and 5.4 μm and respective geometric standard deviations of 1.36, 1.50, 1.10, and 1.10. Details of the tracer analysis methodology can be found elsewhere and are only briefly presented here (Byrne et al. 1995; Lai et al. 1999, 2001a).

The super-micrometer particles used were porous silica spheres, supplied by Phase Separations, Ltd. (Clwyd, UK). The particles were labeled with dysprosium ($^{164}$Dy) using a technique described by Jayasekera et al. (1989) and were dispersed using a Palas RBG-1000 powder dispersion generator (Karlsruhe, Germany). The aerosol was passed through a tube containing a 0.4 MBq Americium-241 radioactive source; using the calculations of Cooper and Reist (1973), it was estimated that for the aerosol flow rate used, the ratio of the residence time of the aerosol in the tube and the characteristic source strength used was greater than unity, so that aerosol Boltzmann equilibrium charge distribution would be reached. The submicrometer particles were generated by nebulizing a dilute solution of indium ($^{115}$In) acetylacetonate.

The deposition of the particles on rough and smooth test surfaces was investigated in a test chamber. Detailed descriptions of this experimental facility can be found in Lai et al. (1999). Figure 1 is a schematic diagram of the overall experimental configuration. The aluminum chamber is a cube with 2 m sides, with a door in one of the walls. The chamber has a provision for holding 2 air filters on the door panel; these are used for aerosol decay rate constant determination. The test chamber is relatively airtight: SF$_6$ tracer gas concentration decay measurements yielded an air exchange rate of 0.06 h$^{-1}$. Suspending fans from the ceiling can control air circulation in the chamber, and Figure 2 shows a typical fan arrangement and typical locations of the rough and smooth samples. Byrne et al. (1995) made tracer gas measurements at 16 widely-distributed locations in the chamber under the lowest airflow condition chosen for the present work (details are provided later). The 16 locations included points at a distance of 2 cm from the corners of the chamber, and a variation in a tracer concentration of <1.5% was found between these points and a point in the center of the chamber, leading Byrne et al. (1995) to the conclusion that the air was well stirred. Based on this conclusion, well-stirred conditions for the other 2 higher flow velocities employed in the present work were therefore assumed. However, it should be noted that anemometer measurements could not be made within distances of a few centimeters from the corners of the chamber by Byrne et al. (1995) or in the present work, and therefore it could not be categorically concluded that turbulent eddies did not exist.
in the corners of the chamber. For this reason, in choosing the location of the test roughness elements in the present work, the corners of the chamber were avoided for all 3 flow regimes, and the elements were positioned in the center of the chamber wall.

To optimize thermal stability inside the test chamber, the entire external walls, with the exception of the horizontal floor, were insulated by 2.5 cm thick expanded polystyrene foam sheets. This was particularly important for studying the deposition of submicrometer particles since it reduced the effect of thermophoresis (Nazaroff and Cass 1989). The temperature variations over the chamber surfaces were measured by using copper-constantan (T-type) self-adhesive fine precision thermocouples by Omega Inc. (Colorado) with an accuracy of 0.5 K. The output signal was displayed by a factory-calibrated digital thermometer (Digitron T228, Herts, UK) with an instrument accuracy of 0.2 K. The whole temperature measuring system was calibrated in situ before actual measurements were made.

Two series of temperature measurements were made in the test chamber: spatial temperature variations along an interior wall (on which roughness elements were attached) and spatial temperature variations between that wall and the central core of the chamber. The results revealed that only small spatial variations (i.e., <0.3 K) in temperature existed in the test chamber, and it can be inferred that thermophoresis is not an important contribution to the particle deposition mechanisms investigated.

**Arrangement of Fans in the Test Chamber**

Small axial fans (with fan blade lengths in the range of 7 to 15 cm) were used to establish the required airflow conditions inside the test chamber, and these were of 2 types: 24 V, 2.4 W dc and 220 V, 20 W ac. Three different fan arrangements, resulting in 3 different airflow conditions, were adopted for testing the influence of flow velocity on the rate of particle deposition. In airflow scheme A, one dc fan was positioned at the center of the ceiling, pointing downward, and at a height of 1.5 m measured with respect to the floor. In airflow scheme B, 2 ac fans were positioned at the center of the ceiling, pointing downward,
and at a height of 1.0 m measured from the floor. In scheme C, 2 ac fans (1.0 m from the floor) and 1 dc fan (1.5 m from the floor) were used, also pointing downward. The minimum airflow velocities in the chamber resulted from fan arrangement A, and the maximum from fan arrangement C.

Detailed airflow profiles for scheme C, which involved 3 fans, are shown in Figures 3a (mean air speed) and 3b (turbulence). The data shown was generated using a Dantec omni-directional hot-film anemometer with a 54N10 multichannel flow analyzer as the flow measuring device. An anemometer reading was taken

Figure 3. (a) Mean and (b) fluctuation flow velocity measured at 40 cm above the test chamber floor by hot-film anemometer. The plots were generated by interpolating the mesh data using inverse distance weighting of the data.
at each of 18 equally-spaced locations in the left half of the test chamber. The sampling frequency was 2 Hz and the sampling time for each location was 10 min. During the measurements, the sensing element was 40 cm measured from the floor. Due to the physical size constraint of the measuring probe, the nearest measuring position to the chamber wall was at a distance of approximately 20 cm. It can be seen from Figure 3a that the mean air velocity is very symmetric along the y axis of the chamber, with peak mean flows occurring beneath the locations of the 2 larger fans. Figure 3b indicates that the turbulent component is less symmetric, and it is thought that this might be due to the random nature of the turbulence. Directly below the central line of the chamber, the measured mean and turbulent velocities were found to be 1.5 and 0.3 m s\(^{-1}\), respectively. In comparison, the corresponding mean and turbulent velocities measured in the same location with fan arrangement A were 0.3 and 0.1 m s\(^{-1}\), respectively.

**Arrangement of Sample Elements in the Test Chamber**

A key objective of the present study was to compare particle deposition fluxes onto smooth and rough surfaces. Two different surface textures were tested: one surface was composed of regular arrays of three-dimensional roughness and the other was a plain smooth surface. The dimensions of the roughness element are shown in Figure 4. For the smooth surface, the dimensions of the samples were 30 mm (L), 6 mm (W), and 4 mm (D).

Figure 5 shows the arrangements of the smooth and rough surfaces mounted on the vertical wall of the test chamber. The 2 surfaces were placed close together (approximately 20 cm separation between columns), and the horizontal levels of the surfaces were then adjusted so that the sampling sections were located at the same height measured above the chamber floor (approximately 50 cm). The symmetrical arrangement of fans inside the chamber aimed to ensure that the mean and fluctuation flow velocities adjacent to the wall were symmetrical in the spanwise direction and that any spatial effects between 2 adjacent sample surfaces were therefore minimized. Pencil marks were made on the vertical wall to facilitate fixing of the tested surfaces in the same position for each experimental run, thereby reducing the error associated with spatial concentration variations (if any) of the aerosol in the chamber.

For each experimental trial, 4 rough samples and 5 smooth samples were obtained. It was obviously important to create a homogeneous environment for the fluid to flow along the sampling surfaces, and this could best be achieved by covering the whole vertical chamber wall with the roughness elements. However, time constraints and the limited manpower available made it impossible to fabricate enough roughness elements. A compromise was taken; the roughness elements that would be sampled were surrounded by an array of the same roughness elements so that adequate pathways were provided for the flow to fully develop before reaching the samples. Sparrow et al. (1982) and Jubran et al. (1996), in their forced convection channel flow experiments, both showed that the flow reached a fully developed state after 5 rows of three-dimensional roughness elements. Therefore it was considered feasible to adopt a similar strategy in the present work, and 30–50 elements were arranged to surround the sample sections in both transverse and longitudinal directions.

**TRACER ANALYSIS AND EXPERIMENTAL PROCEDURE**

The tracer aerosol analysis method adopted in this work is neutron activation analysis (NAA). The rare earth elements dysprosium (\(^{164}\)Dy) and indium (\(^{115}\)In) were considered suitable aerosol tracers for the present work since both elements occur naturally in low concentrations and produce short-lived radionuclides following neutron activation. NAA is based on the principle that radioactivity of a characteristic energy may be induced in a material through bombardment with neutrons (from an external source, such as a nuclear reactor). By counting the
radioactive emissions resulting from subsequent decay of the radionuclide formed, and making a comparison with the emissions from a known mass of the same material irradiated and analyzed under the same conditions, the mass of material of interest in the sample can be determined. Detailed descriptions can be found elsewhere (Byrne et al. 1995; Lai et al. 1999, 2001a).

Since the primary sample materials used in the present investigation were Perspex, it was considered that an electrostatic charge on the samples might result in additional aerosol deposition that could not be quantified in this work. It is therefore necessary to reduce any possibility of electrostatic charge accumulating on the test surfaces, and a commercial available anti-electrostatic foam (antistatic cleaner from RS Components, Northants, UK) was employed for this purpose. A series of preliminary experiments was carried out in order to test the efficiency of the foam, and the results indicated that it effectively reduced the static charge on Perspex surfaces. Therefore before each experiment, antistatic foam was freshly applied over all the samples (Lai et al. 1999). In addition, a thin coating of liquid paraffin oil was applied evenly onto the sample surfaces. This measure was adopted because it is widely accepted that solid particles do not always perfectly adhere onto surfaces due to the mechanisms of particle resuspension and particle bounceoff, and the function of the paraffin oil was to eliminate these effects for the solid particles generated, i.e., the super-micrometer particles in the present work.

Each experimental run commenced with a particle generation period of approximately 5 min. Concentration decay measurement was then initiated by sampling the chamber air using a dichotomous air sampling system with switching valves, so that as one 10 min sample was collected, the filter paper in the other holder could be changed. The filter papers, which were Whatman 542 hardened ashless filters, were transferred to clean plastic bags and remained in these bags during neutron activation analysis.

The duration of each air sampling period was of the order of 120 min. With this arrangement, the typical sample air volume drawn from the chamber during the experiment was only about 7% of the chamber total volume and therefore the particle concentration was not significantly affected by air extracted. After each experiment, all the Perspex samples were carefully transferred to clean plastic bags and underwent NAA together with the filter paper samples. The concentration measurements were repeated at least 3 times for each particle size.

In the next section of this paper, the ratio of particle mass flux to roughness elements and to smooth surfaces is presented. The mass flux, \( J \), can be evaluated from the following expression:

\[
J = \frac{M_{\text{sample}}}{A_{\text{sample}} \cdot t},
\]  

where \( M_{\text{sample}} \) is the tracer aerosol particle mass detected on a single smooth or rough sample and \( t \) is the sampling time. It should be noted that for the rough samples, the smooth base area, \( A_{\text{sample}} \), of the rough surface sample (12 × 6 mm) was considered rather than the total area available for aerosol deposition. This is the general practice adopted in heat transfer research (Rowley and Patankar 1984) and has the advantage of enabling direct comparison of transfer coefficients for different configurations.

Precautionary measures were employed in order to minimize cross-contamination due to residual tracer aerosol between consecutive experiments. Between experiments, the chamber door was locked, a flexible duct was connected to a duct outlet, and the chamber air was then vacuumed for 2–4 h. The vertical wall on which the samples had been fixed was cleaned with water and alcohol. Only one experimental run was ever carried out in a single day so that the process of aerosol deposition ensured that the residual aerosol concentration would be negligible in subsequent experiments.

RESULTS AND DISCUSSION

Effect of Air Velocity and Particle Size on Particle Rate Loss Coefficient

The rate of aerosol concentration decay in an enclosed chamber should be exponential (i.e., first-order decay) if particle coagulation is not a significant particle loss process. The decay of an initial aerosol concentration \( C_0 \) can be described as follows (Nazaroff et al. 1993):

\[
C(t) = C_0 \exp(-\beta t),
\]  

where \( \beta \) is the particle loss rate coefficient (time\(^{-1}\)) and \( t \) is the elapsed time.

Figure 6 shows the best fitted mass concentration decay curves for 4 particle sizes studied for 2 different fan speed arrangements: the highest and slowest airflow speeds. These data were obtained without roughness elements on the walls of the chamber, because previous experiments by Byrne et al. (1995) in the same chamber suggested that the change in overall decay rate that would result would be insignificant for roughness elements of the dimensions of interest to the present work. For comparison, the best-fitted results obtained by Byrne et al. (1995) were also shown in the figure. Replicate runs showed that the experimentally-determined particle rate loss coefficients were very consistent from trial to trial, and therefore it was considered that 3 trials for each particle size were sufficient. The experimental data showed that the particles decay exponentially and can be described quantitatively by Equation (2). The average \( R \)-squared values were 0.58, 0.91, 0.94, and 0.95 for particle sizes 0.7, 2.5, 4.5, and 5.4 \( \mu m \), respectively. Except for the 0.7 \( \mu cm \) particles, the deposition rate loss coefficients followed a generally anticipated trend: loss coefficients for high air speed were significantly higher than those for the low air speed setting for the 3 larger particle sizes studied.
For those particles studied in the present work and considering only gravitational settling and Brownian and turbulent diffusion removal mechanisms, modeling predicts that the loss coefficient should be entirely predicted by gravitational settling (Lai and Nazaroff 2000). The corresponding settling velocity is shown in Figure 6 for comparison. It can be seen that the experimentally determined loss rates are larger than those predicted by the settling velocity. The discrepancy is not limited to the present study; a similar observation was reported by Thatcher et al. (2001), who studied the effect of fan speed on particle loss in an experimental test room for particle sizes from 0.5 to 10 μm. A satisfactory explanation for this observation is not yet formulated, but plausible reasons include (and are not limited to) particle inertia effects.

**Effect of Air Velocity on Particle Deposition**

The particle rate loss coefficient, discussed above, is a single parameter that quantifies the sum of all the mechanisms by which aerosol is removed. In order to gain a greater understanding of the individual contributions to the aerosol removal mechanism, direct deposition experiments were performed for the 3 different air speeds, using a single particle size, on rough and smooth surfaces. For this series of experiments, 4.5 μm particles were chosen, based on the belief that this particle size would exhibit inertial effects in response to different airflow intensities. Figure 7 shows the relative deposition of 4.5 μm particles onto rough samples compared to smooth samples, with the deposition on the smooth samples being normalized to unity. Values of 0.4, 1.0, and 1.6 were found for the fan arrangements A, B, and C, respectively. The first two of these results are counterintuitive, i.e., deposition on the rough surface is less than or equal to deposition on the smooth surface.

A knowledge of the detailed airflow pattern close to the chamber wall, where the elements were mounted, is important in explaining the above observation. However, as already mentioned, air velocity measurements could not be made within 20 cm of the wall due to the physical constraints of the anemometer system. However, using the available airflow data, Computational Fluid Dynamics (CFD) simulations for the chamber were carried out (Byrne et al. 1995; Holmberg and Li 1998) and some conclusions regarding the airflow in the vicinity of the roughness elements can be derived from these studies. The CFD simulated velocity plots indicated a boundary layer upward flow, and so a laminar boundary layer thickness can be estimated by assuming this flow direction and considering a situation where the boundary flow commenced at the edge of the floor (z = 0 in
Figure 7. Relative ratio of particle deposition flux of 4.5 μm size for the three-dimensional roughness elements to smooth samples under 3 different fan arrangements.

Figure 2). Taking the boundary layer velocity to be 50 cm/s upward (Figure 3), the nominal laminar boundary layer thickness can be calculated by 5/(Re)^0.5 (Fox and McDonald 1998) and is estimated as 29 mm. Since the turbulent nominal boundary layer thickness is always larger than the corresponding laminar flow, it can be argued that the boundary layer thickness was significantly larger than the roughness height of the elements and in light of this argument, a plausible explanation can be formulated by considering the flow characteristics in the vicinity and within the protrusion elements of the rough samples to explain the counterintuitive observations found in Figure 7.

As shown in Figure 4, the ratio of the height of the individual protrusion elements to the separation between elements is unity, which favors a confined cavity flow between elements and is likely to cause substantial reduction in particle transportation and deposition. A supporting observation was made by Zhao and Trass (1997), who carried out electrochemical mass transfer measurements on roughened pipe surfaces with geometrically similar V-shape grooves and found that deep grooves resulted in a lower mass transfer coefficient. These results can be explained by considering that the deeper the cavity, the more confined the inside cavity flow and the less interaction there is with the main flow. The penetration of turbulent energy from the core flow to the cavities and hence the mass transfer coefficient is thus affected.

In the context of the above discussion, the experiments of Garimella and Eibeck (1990) should also be noted. These researchers determined convective heat transfer coefficients for water flow in arrays of heat generating regular modules deployed along one wall of a flat rectangular duct. They concluded from their measurements that increasing the spacing between elements increases the heat transfer coefficient.

In summary, the results of other researchers have indicated that increasing the separation between the fixed height of protrusion elements reduces flow confinement and results in greater interaction with the main flow. In the present work, however, the confined flow that develops between the fixed configuration of roughness elements is unfavorable for enhancing particle deposition. In this series of experiments, where a fixed particle size is used, increasing particle inertia by means of particle velocity enhances deposition. Figure 7 verifies this by showing that the particle deposition increases with the fan speed in the test chamber.

Effect of Particle Size on Deposition

The relative deposition onto rough and smooth samples of 4 different particle size distributions was explored under a single airflow condition; for this particular set of experiments, the highest flow speed was selected. Figure 8 shows the results for 0.7, 2.5, 4.5, and 5.4 μm particles. It can be seen that, for a fixed fan configuration, there is no obvious deposition increment on the rough samples relative to the smooth samples for the 0.7 and 2.5 μm particles, but the percentage increment increases significantly for the larger particle sizes and is 2.4 for the 5.4 μm particles. Since particle relaxation time is a function of particle diameter, it is possible that the observed enhanced deposition might be attributable to inertial effects associated with the larger particles. Another recent study (Lai and Nazaroff 2001) has shown that the deposition ratio on sandpaper with a mean roughness height of 0.25 mm,
EFFECT OF ROUGH SURFACES ON DEPOSITION

Figure 8. Relative ratio of particle deposition flux of the three-dimensional roughness elements to smooth samples for the highest flow arrangement.

relative to a smooth surface, can be as high as 6 for 2.2 \( \mu m \) particles.

Although not shown in Figure 8, a comparison of the present results can be made with the data of Lai et al. (2001a), who carried out measurements under turbulent channel flow using the same 4 particle size distributions and the same roughness elements as were employed in the present work. In the turbulent channel, the average deposition ratio (on rough surfaces relative to smooth) for particle sizes 0.7, 2.5, 4.5, and 7.1 \( \mu m \) were 17, 13, 6, and 8, respectively. The difference between these values and the present results can be plausibly attributed to the turbulent airflow velocity in the present work being substantially less than that studied in the ventilation duct. In addition, a well-stirred airflow pattern existed in the present work, as was indicated in Figure 3, and was obviously very different from the flow in the ventilation duct where a clear airflow direction prevailed.

CONCLUSIONS AND REMARKS

Particle deposition indoors can be an important loss process. In order to enhance the current understanding of the mechanisms involved aerosol decay and deposition, measurements were made in a room-sized test chamber. The deposition of 4 monodisperse tracer labeled particle distributions was studied, and the influences of chamber surface characteristics, particle size, and air velocity on particle deposition were examined.

Aerosol deposition on 2 different sample types were investigated under 3 different well-stirred conditions: smooth Perspex samples and regular arrays of three-dimensional roughness elements. It was observed that under the lowest and medium airflow conditions studied, particle deposition on the regular arrays of roughness elements were found to be less than, or not significantly greater than, deposition on the smooth samples. A plausible reason for this observation is that a low velocity cavity flow exists between 2 protrusion elements, which generates a barrier between the main bulk flow and the flow adjacent to the element surfaces. It was also observed that particle size influences deposition onto the roughness elements studied, with particle deposition increasing as particle size increases.

The data generated in this work should be extended to consider a wider range of surface types, and an important parameter that should be measured is particle deposition velocity on these surfaces. Detailed air velocity measurements within close proximity of the surfaces, using a technique such as Laser Doppler Velocimetry, is also clearly necessary. Furthermore, computational fluid dynamics (CFD) should be used as a tool to enhance understanding of flow structures around rough elements, but in order to achieve this, modeling advances are first required, as current CFD models cannot adequately simulate the random surface textures of surfaces such as sandpaper.

REFERENCES


