TEMPerature effect on emission of Airborne wear particles from car brakes

It is known that wearing of car brakes is one of the main sources of airborne particles. Some of these particles are deposited in the respiratory tract of human body and cause adverse health effects. Therefore, it is necessary to evaluate emissions of airborne wear particles with high accuracy.

In the present study we investigate the influence of temperature on the emission of airborne wear particles from two low-metallic material / cast iron pairs used in car brakes. The low-metallic materials are code-named M1 and M2. The tests are conducted by use of a pin-on-disc machine placed in a chamber which allows collecting airborne particles. The temperature $T$ is measured by a thermocouple installed in the disc. The concentration and distribution of airborne particles with characteristic size $d$ from 0.0056 to 10 µm are measured by a TSI fast mobility particle sizer 3091 and TSI optical particle sizer 3330. The sliding velocity $v_{sl}$ changes due to the regime of acceleration–deceleration to provide a slow variation of $T$. Based on the measured particle concentration and known rate of the air exchange between the chamber and environment, we calculate the energy particle emission rate $e$ — the number of airborne wear particles per Joule of the friction energy.

Particles are classified in three types: ultrafine particles ($d=0.0056–0.1$ µm), fine particles ($d=0.1–0.56$ µm) and coarse particles ($d=0.56–10$ µm). The energy particle emission rates corresponding to these particle types are denoted by $e_u$, $e_f$ and $e_c$.

The experiments show that the particle emission intensifies and the average particle size decreases with increasing $T$. There exist critical temperatures $T_l$ and $T_u$ at which the rates $e_f$ and $e_u$ rise stepwise by several orders of magnitude. The dominating particle type changes due to the following sequence: coarse particles $\rightarrow$ fine particles $\rightarrow$ ultrafine particles. The M1 / cast iron pair has $T_l=40–91$ °C and $T_u=169–189$ °C, while the M2 / cast iron pair has $T_l=68–95$ °C and $T_u=168–188$ °C. The sliding velocity and contact pressure have a slight effect on the critical temperature $T_u$. The particle size distribution has peaks at 0.011, 0.19 and 0.9 µm.

Temperature-dependent emission of airborne wear particles from the M2 / cast iron pair