Nanoparticle fraction of the inhalable dust in gas tungsten arc welding of stainless steel and manual grinding of steel

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Nanoparticles are released into workplace air in many processes, such as welding and grinding (e.g., Zimmer and Maynard, 2002; Elihn and Berg, 2009), but their fraction of the inhalable dust is rarely determined, especially from the breathing zone. This is partially due to lack of appropriate methods and devices to measure nanoparticles.

Here, nanoparticle fraction of the inhalable dust was determined using a customized cyclone before a conventional IOM-sampler (SKC Inc., USA). The cyclone cuts off particles with aerodynamic diameter (D_a) > 0.5 µm. Workers carried both conventional and modified IOM-sampler, and a diffusion size classifier (DiSCmini, Matter Aerosol AG, Switzerland). DiSCmini has an impactor that removes > 0.7 µm particles.

The measurements were performed in two workshops. The first is a welding workshop with a gas tungsten arc welding (GTAW) as a main welding technique. The welder studied processed stainless steels (SS) (1.4307/304L and 1.4404/316L). The second workshop manufactures hydraulic cylinders. The worker studied was a machinist whose work included a lot of steel (355 SBMX) grinding with a handheld, pneumatic belt sander.

IOM-samples were collected on nitrocellulose membranes (pore size 0.8 µm) (Merck Millipore Corp., Germany) using a flow rate of 2.0 litres per minute. Flow rates were calibrated before and during each measurement day with a Gilibrator (Sensidyne, USA).

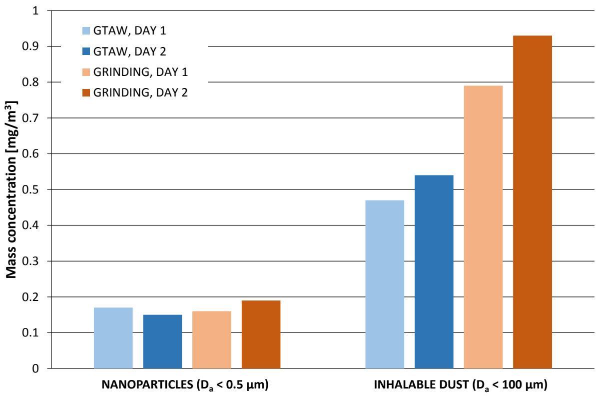

Figure 1. Mass concentrations of nanoparticles and inhalable dust in the GTAW of SS and grinding of steel at two different measurement days at each workshop.

The mass concentrations of nanoparticles and inhalable dust are shown in Figure 1. The mass concentration of nanoparticles was similar in both works but nanoparticle fraction of the inhalable dust was higher in the GTAW. In the GTAW, the nanoparticle fraction was 36 % and 28 % on day 1 and day 2, respectively. In the grinding, it was 20 % of the inhalable dust on both days.

Averaged lung deposited surface area (LDSA) and number (C_n) concentrations, and mean size (D_p) of particles with D_p < 0.7 µm measured with the DiSCmini are presented in Table 1. The GTAW of SS produces approximately 28 times higher C_n and 15 times higher LDSA concentration of < 0.7 µm particles than the grinding.

Table 1. Lung deposited surface area (LDSA) and number (C_n) concentrations, and mean size (D_p) of particles (< 0.7 µm) produced in the GTAW of SS and grinding of steel. The values are averages of 3-5 periods of 4 minutes with standard deviations.

Work	**LDSA (µm²/cm³)**	**C_n (1/cm³)**	**D_p (nm)**
GTAW	$(3.0\pm1.5)*10^3$	$(25\pm10)*10^5$	28±2
grinding	$(0.19\pm0.09)*10^3$	$(0.9\pm0.4)*10^5$	42±16

The results show that nanoparticle fraction can comprise up to one third of the inhalable dust in the GTAW workshop. The LDSA concentration of the particles produced in the GTAW of SS is also higher than in the grinding of steel with a handheld, pneumatic belt sander. Both of the measured dusts contain metals and nanoparticles, thus the use of the appropriate respiratory protective equipment is recommended.

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