Verifying modified EAD (MEAD) used in measuring metal fume nanoparticle and charactering its exposure concentration during gas metal arc and flux cored arc welding processes

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The whole study was conducted to verify the suitability of MEAD on measuring metal fumes with high dielectric constant properties and characterize metal fume nanoparticle exposure by using the MEAD during gas metal arc and flux cored arc welding processes.

Results show that the concentrations estimated for the TB and A region, the results obtained from the NSAM for the testing welding processes quite comparable to those corresponding values obtained from MEAD (Figure 1). Considering both NSAM and MEAD sharing the same measuring principles, comparable results obtained from both instruments could be theoretically expectable. After normalization, no significant difference can be found between the results obtained from SMPS and MEAD (Figure 2). It is concluded that the obtained MEAD results are suitable for assessing metal fume nanoparticle exposures. Table 1 shows the size distributions of fume nanoparticles obtained from welding processes within current intensity 120A measured by the MEAD. From the tested welding operation conditions, a uni-modal was found for fume nanoparticles emitted from the selected welding processes. The CMD increase with the current intensity, it could be mainly explained by the higher arc temperature. By comparing the results shown in Table 2 and Table 3, significant differences can be found in the fractions of nanoparticles deposited on each of the three regions while different exposure metrics were adopted. Our results clearly indicate the importance for simultaneously predicting both the surface area and number concentrations of nanoparticles deposited on different regions of the respiratory tract for fume nanoparticle exposure assessments.

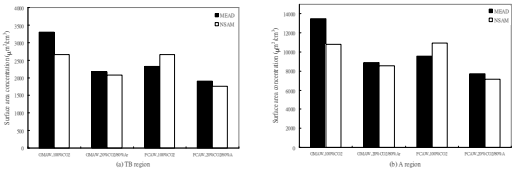

Figure 1. Confirmations of nanoparticles deposited on (a) TB region and (b) A region for data derived from MEAD and NSAM measured results.

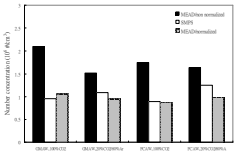

Figure 2. Comparing number concentrations obtained from SMPS with that from MEAD (a) non-normalized (b) after being normalized.

Table 1. Size distributions of fume nanoparticles (1－1000 nm) obtained from the testing welding processes were measured by MEAD.

welding condition		Number-based size distribution (nm)	
welding type/electrode	shield gas	CMD (rang)	σ_g
GMAW/KM 56	100%CO_2	124 (100 - 158)	1.70
	20%CO_2/80%Ar	117 (110 - 124)	1.81
FCAW/KFX 71T	100%CO_2	127 (116 - 133)	1.82
	20%CO_2/80%Ar	116 (110 - 120)	1.81

Table 2. Estimated number concentrations (10^6 #/cm^3) of fume nanoparticles deposited in the H, TB, and A regions of the respiratory tract for data obtained from the testing welding process.

welding condition		total deposited	H	TB	A
welding type/electrode	shield gas	concentration	Fraction(%)	Fraction(%)	Fraction(%)
GMAW/KM 56	100%CO_2	2.07±0.458	19	16	65
	20%CO_2/80%Ar	1.51±0.095	19	16	65
FCAW/KFX 71T	100%CO_2	1.69±0.207	18	17	65
	20%CO_2/80%Ar	1.61±0.155	17	17	66

Table 3. Estimated surface area concentrations (10^4 $\mu m^2/cm^3$) of fume nanoparticles deposited in the H, TB, and A regions of the respiratory tract for data from the testing welding process.

welding condition		total deposited	H	TB	A
welding type/electrode	shield gas	concentration	Fraction(%)	Fraction(%)	Fraction(%)
GMAW/KM 56	100%CO_2	2.42±0.810	29	14	57
	20%CO_2/80%Ar	1.62±0.132	32	13	55
FCAW/KFX 71T	100%CO_2	1.74±0.270	32	13	55
	20%CO_2/80%Ar	1.35±0.132	29	14	57

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