Numerical Study and Simulation in COMSOL Multiphysics of the Dilution Process during Dust's Sampling in Dry Machining

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Introduction: Dilution's issue during dry machining has risen in recent years with the interests of environmental researchers and engineers. For adequate sampling of dust with Scanning Mobility Particle Sizer (SMPS), the dilution system was used for best particle's concentration during air quality measurement.

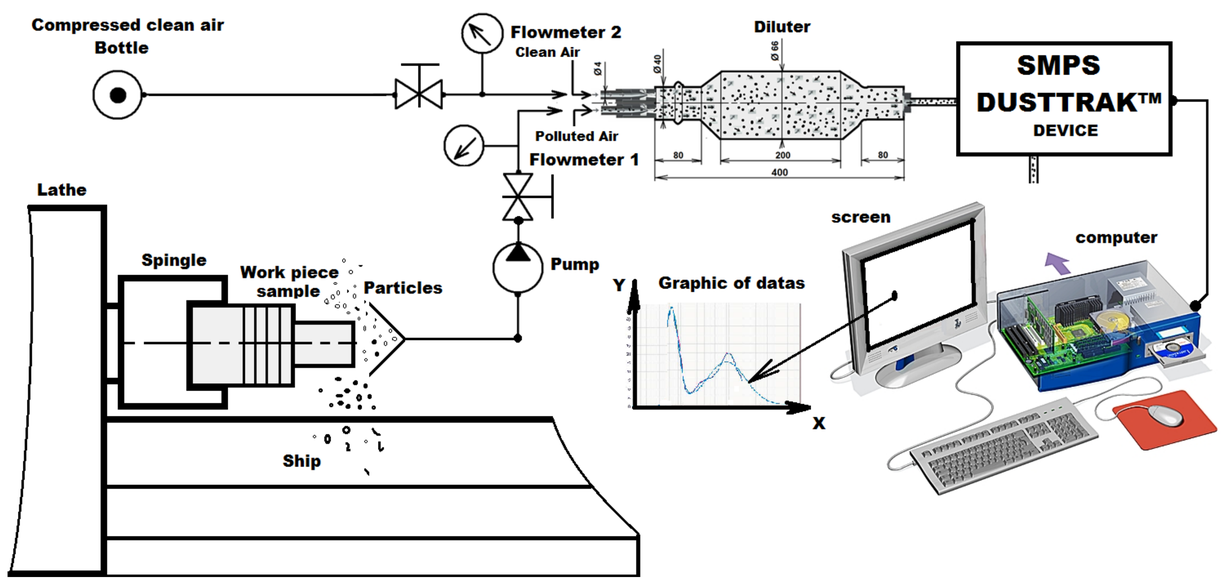

Figure 1. Experimental setup.

Computational Methods: We used the NAVIER-STOKES equations and CFD k-ε model to obtain the graphic simulation of different state of dilution during the variation of clean air added.

$$\frac{\partial \rho k}{\partial t}+\frac{\partial \rho k u_i}{\partial x_i}=+\frac{\partial}{\partial x_j}\left[\left(\mu+\frac{\mu_t}{\sigma_k}\right)\frac{\partial k}{\partial x_j}\right]+G_k+G_b-\rho\varepsilon-Y_M+S_k$$

$$\frac{\partial \rho \varepsilon}{\partial t}+\frac{\partial \rho \varepsilon u_i}{\partial x_i}=+\frac{\partial}{\partial x_j}\left[\left(\mu+\frac{\mu_t}{\sigma_k}\right)\frac{\partial \varepsilon}{\partial x_j}\right]+C_{1\varepsilon}\frac{\varepsilon}{k}\left(G_k+C_{3\varepsilon}G_b\right)-C_{3\varepsilon}G_b-C_{2\varepsilon}\rho\frac{\varepsilon^2}{k}+S_\varepsilon$$

Figure 2. 3D design of diluter: (a) inlet of clean air; (b) inlet pollute air ;(c) outlet of mixture.

Results: the graphic simulation of different stats of dilution have shown the good result when the inlet clean air, the inlet polluted air and outlet mixture was in the same jet direction.

Table 1. Different alternatives and test of dilution

Test	Alternatives A or B			
	Polluted air		Clean air	
	Speed(m/s)	Flow (cc/min)	Speed(m/s)	Flow (cc/min)
1	4.5	33929200.8	0.0	0000000.0
2			0.5	3769911.2
3			1.0	7539822.4
4			1.5	11309733.6
5			2.0	15079644.8
6			2.5	18849556.0
7			3.0	22619467.2
8			3.5	26389378.4
9			4.0	30159289.6
10			4.5	33929200.8

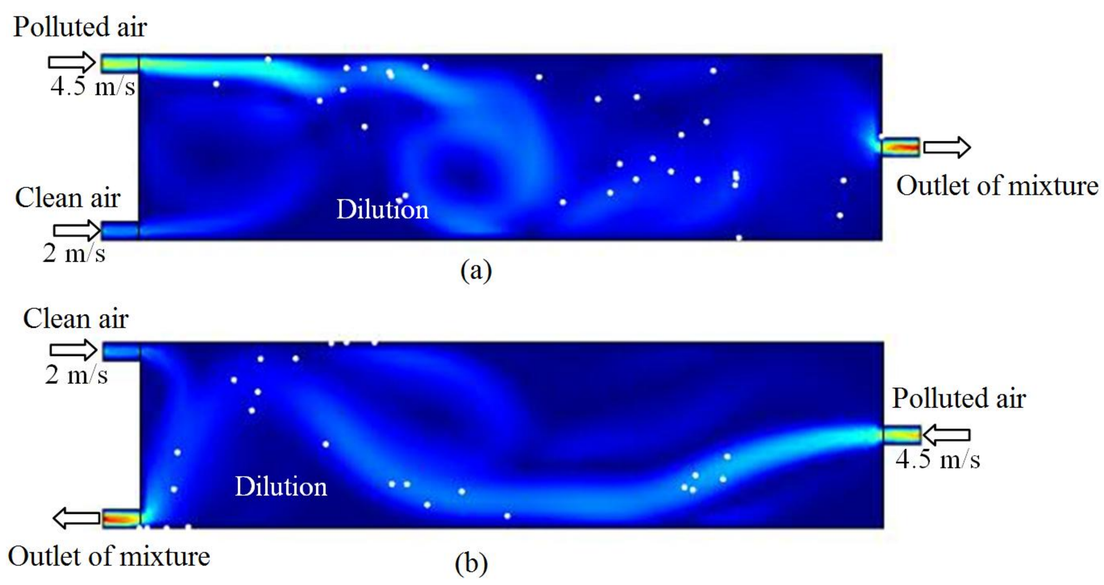

Figure 3. Graphic of simulation in COMSOL Multiphysics.

Conclusions: Our work consisted to simulate a dilution process during the sampling of dust during dry machining. The simulation have shown best dilution in the same jet direction with mean of dilution factor at 95% confidence interval.

References:

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2. Knibbs, L.D. &al, A simple and inexpensive dilution system for the TSI 3007 CPC, J Journal of Atm.Env., Vol.41 (21), pp.4553-4557, (2007).