Simulation and Optimization of the Speed Flow in COMSOL Multiphysics® During the Suction of the Dust Pump for Granite Polishing Operation

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Abstract

Polishing is one of the oldest finishing processes that are necessary because of the commercial value given to aesthetics in the construction product. Several companies in Quebec (Estrie region) are deployed in the finishing sector where single had in 2009 have sailing in about 14,000 tons of granite to a turnover of 1.5 million $ CAD. This favorable economic growth in this sector greatly obstructs polishing worker's conditions where the exposure to emissions of crystalline silica dust is so high. Some toxicological studies are identified this pollutant responsible of a particular type of lung cancer: silicosis. The protection of workers is at the center of the concerns of stakeholders (CSST, Industries, IRSST and Universities). The scientific interest is shifting to the systematic study of the polishing "process" to find operational solutions to the intrinsic reduction or reducing near-field emissions of fine and ultrafine dust. Measure the total concentrations of dust emitted by polishing of granite was more important in the evaluation of workers' exposure to crystalline silica as quartz in these industries.

In general, granite dust emitted during polishing is high concentrations and sampling equipment as DUSTTRAK, SMPS, APS does not allow measurements in such conditions. Therefore, we must develop a dilution system to better sampling. Moreover, it has been shown by researchers in air quality when the dust extraction polishing system creates excess turbulence in the flow, and then there is a significant loss of granite particles in the diphasic flow. That was the reason of the bad measurement given by sampling devices in air quality. In the project, we will use COMSOL Multiphysics for simulating flow in the dust extraction during polishing of granite. We used the Navier-Stokes equations to model the flow and the k-Ɛ numerical method to graphically simulate the flow. It was clear from our results that for flow velocities 0.2 to 1.5 m/s the air quality sampling devices gave the good result.

Reference

Amet, E., Maître, T., Pellone, C., Achard, J.-L. (2009). 2D Numerical Simulations of Blade-Vortex Interaction in a Darrieus Turbine. Journal of Fluids Engineering, 131(11), pp.1111031-11110315
Beaudry, C.; Dion, C.; Gérin, M.; Perrauld G.; Bégin, D.; and Lavoué, J., (2011). Exposition des travailleurs de la construction à la silice cristalline : Bilan et analyse de la littérature, Rapport de recherche IRSST, R-692, Montreal, 95p.
Byrne, G.; and Scholta, E., (1993). Environmentally clean machining processes –a strategic approach, Annals of the CIRP, Vol. 42 (N˚1)1, pp.471–474.
Cheng, C.H., and Hung, K.S., (2005). Experimental and numerical study of three-dimensionnal flow field in minienvironment, int. J. of Energy and building Vol. 37 pp. 579-586.
Djebara A., Wenga, N.B., and Songmene, V., (2012). Pollutant Emissions control in the Machine Shops, NanoQuebec conference, march 20-21, EHS-02.
Djebara A., (2012). Caractérisation des poussières d'usinage et amélioration de l'échantillonnage, Thèse de Doctorat, ÉTS/LIPPS, Génie mécanique.
Fan, R., and Fei, L., (2011). Estimation of fine dust particles distribution in machining workshop based on COwZ model, Chinese Journal of mechanical engineering, Vol.24, pp.1-9.
Hinds W.C., (1982). Aerosol Technology : Proprieties, Behavior, and Measurement of Airborne Particles, John Wiley & Sons, Inc, USA.
Hirsch, C. (2007). Numerical computation of internal and external flows: introduction to the fundamentals of CFD (nouvelle ed.). Oxford : Butterworth-Heinemann. Consulté le 2 juin 2013, tiré de Engineering Village: http://www.engineeringvillage.com/controller/servlet/
Kathleen, M.R.,(2002). Health effects of occupational exposure to respirable crystalline silica, NIOSH Hazard Review, Columbia Parkway Cincinnati, OH 45226-1998, N˚ 2002-129, 20p.
König, W., and Rummenhöller, S., (1994). Ecological manufacturing, Production Engineering , German Academic Society Engineering, Vol 1 (N˚2),pp.1–4.
Lai, A.C.K., Wang, K. and Chen, F.Z. (2008) Experimental and numerical study on particle distribution in a two-zone chamber. J. Atmospheric Environment Vol.42, 1717-1726.
Liu, Z.; and Huang, C., (2009). A technological study on granite grinding. Key. Engineering Material, Vol.416, pp 316-3320.
Löhner, R. (2008). Applied computational fluid dynamics techniques: an introduction based on finite element methods (2nd ed). Angleterre: John Wiley & Sons
Lu, W., Howarth, A.T., Adam, N. et Riffat, S.B. (1996). Modelling and measurement of airflow and aerosol particle distribution in a ventilated two-zone chamber. J. Building and Environment, N˚.31, 417- 423.
Rice, F.,(2000). Cristalline silica quartz, WHO, Concise International Chemical Assessment, Geneva, 50p.
Rentsch, R.; Inasaki, I., (1994). Molecular dynamic simulation for abrasive processes, CIRP Annals - Manufacturing Technology, Vol.43, N˚1, pp. 327–330
Song, Y.; Li, X.; Wang, L.; Rojanasakul, Y.; Castranova, V.; Li, H.; and Ma, J., (2011). Nanosilica in human: Identification, characteristic, ans potential damage, Int. J. Toxicologic Pathology, N˚39 , pp.841–849.
Songmene, V.; Balout, B.; Masounave, J., (2008). Clean machining: Experimental investigation on particle formation Part I: Influence of machining parameters and chip formation, Int. J. Environ. Conscious. Des. Manuf. (ECDM), 14 (1): pp.1–16.
Stathopoulos T., Chavez M., Bahloul A., (2011). CFD approaches to predicting dilution from exhaust stacks in urban areas in Sustainability knows no borders, ASHRAE Annual Conference,

June, Montréal.
Wenga, N.B., (2007). Simulation sur CALPUFF et SCREEN de la pollution de l'air par les poussières dans le cadre de l'EIE de la nouvelle carrière à calcaire GRABEMARO au Maroc, Presse de l'Agence de l'Universitaire de la Francophonie, CRESA, Nkolbisson, Yaoundé, 95p.
Wenga, N.B., (2012). Numerical study and simulation in COMSOL Multphysic of dilution process during dust sampling in the dry machining. in proceedings of particle tracing - COMSOL Conference,October 2012 , ID13157, Boston, USA.
http://www.comsol.com/offers/conference2012papers/papers/presentation/area/particle/id/13157/
Wenga, N.B., (2012), "Numerical study and simulation of dust sampling with dilution: Application to machining of AA7075-T6" Encyclopedic of research in Aluminium, Regroupement Aluminium-Centre de Recherche (REGAL), Trois-Rivières, Montréal, Canada.

WHO., (1999). Hazard Prevention and Control in the Work Environment: Airborne Dust, Occupational and Environmental Health, Department of Protection of the Human Environment, World Health Organization, Geneva, WHO / SDE / OEH/ 99.14, 219p.
Zimmer A.T.; Maynard A.D., (2002). Investigation of the aerosols produced by a high-speed, hand-held grinder using various substrates. Journal of Ann. Occup. Hyg., 46: pp.663–702.