Proceedings of the 9th World Congress on New Technologies (NewTech'23)
Brunel University, London, United Kingdom - August 09-11, 2023
Paper No. ICEPR 123
DOI: 10.11159/icepr23.123

Studies for Mitigation Measures for Dust Resuspension from Stockpiles

Umangi Mehta, Vamsi Botlaguduru, Manaswita Bose, Virendra Sethi
[1]Indian Institute of Technology Bombay,
Mumbai 400076, India

204180002@iitb.ac.in, vamsi.bvs@iitb.ac.in, manaswita.bose@iitb.ac.in, vsethi@iitb.ac.in

Extended Abstract

Dust resuspension caused by wind over open stockyard surfaces is a widespread issue in various industries, particularly in ports that handle dusty cargo. Previous research has identified windscreens as an effective measure to mitigate dust resuspension from stockpiles [1]. However, the efficiency of these measures is significantly influenced by factors such as wind conditions, pile and windscreen configuration, and stockpile arrangement [1]. Previous studies conducted using field and experimental methods have been resource-intensive and faced difficulties in establishing a controlled environment that without interfering with ongoing operations [2], and in scaling of the experiments [3]. To supplement these studies, the present work utilized Computational Fluid Dynamics (CFD) simulations to assess the impact of wind erosion on dust resuspension from stockpiles [4] [5][6].

CFD simulations were conducted using a numerical modeling approach to investigate the fluid flow over stockpiles and the resulting dust resuspension. The model was scaled at a ratio of 1:100 to represent two stockpile geometries for bulk materials: a conical pile and a flat oval top pile, both with a height of 11m and an angle of repose of 37˚, with a domain area of 4m (L) x 1m (W) x 1m (H) [1][5]. The domain was discretized using the tetrahedral method, and the lateral walls were assigned symmetry boundary conditions. The bottom wall was set at a roughness of 4 mm with a no-slip condition. Inlet velocity was set at 4 m/s, and the pressure gradient at the pressure outlet was set to zero. The simulations employed the second-order discretization scheme with the SIMPLEC method to enhance convergence. The Reynolds-Averaged Navier-Stokes (RANS) model with the k-epsilon (k-ε) turbulence model was employed for simulations [7]. The simulations were validated against the study data conducted by Billman and Arya (1985) [1].

The simulations aimed to examine the influence of various parameters on the extent of dust resuspension from both conical and flat oval top stockpiles. Case A focused on the configuration of windscreens (shelter effect) by varying the windscreen height, length, and percentage of openings. Case B investigated the impact of wind orientation on the efficiency of windscreens. Case C explored the arrangement of stockpiles (shadow effect) to minimize dust resuspension.

The results were used to validate previous studies and extend the matrix for parameters influencing dust resuspension from stockpiles. The present work showed that for both conical and flat oval top piles, the height of the windscreen should exceed the height of the stockpile to reduce dust resuspension. However, the length and the distance between the windscreen and the stockpile had minimal impact on reducing dust resuspension. The openings in the windscreen played a significant role, with solid screens and 20%-30% openings demonstrated an approximately 80% reduction in dust resuspension. The simulations also highlighted the influence of wind orientation on windscreen performance. It was observed that a windscreen placed before the conical pile can be more efficient in reducing dust resuspension for wind direction variations up to 40˚ as compared to the flat oval top pile due to increase in the exposure surface area in the case of later with changing wind direction. The arrangement of stockpiles showed about 45% reduction in resuspension of dust from the stockpile. Furthermore, exploring the combination of shelter and shadow effects demonstrated about 70% reduction in dust resuspension from stockpiles. These findings align with previous studies on dust control measures, providing further evidence of the effectiveness of windscreens in mitigating dust resuspension from stockpiles.

References

[1] Billman S. and Arya S.P.S (1985) Windscreen Effectiveness for Storage-pile Fugitive-dust Control a Wind Tunnel Study. USEPA. Atmospheric Science Research Laboratory

[2] Cong, X. C., Yang, S. L., Cao, S. Q., Chen, Z. L. Dai, M. X. and Peng. S. T. Effect of Aggregate Stockpile Configuration and Layout on Dust Emissions in an Open Yard (2012). Applied Mathematical Modelling 36, no. 11: 5482–91. https://doi.org/10.1016/j.apm.2012.01.014.

[3] Santiago, J.L., Martín, F., Cuerva, A., Bezdenejnykh, N., Sanz-Andrés, A. (2007). Experimental and numerical study of wind flow behind windscreens, Atmospheric Environment, Volume 41, Issue 30,2007, Pages 6406-6420, ISSN 1352-2310, https://doi.org/10.1016/j.atmosenv.2007.01.014

[4] Novak, L., Bizjan, B., Pralvznikar, J., Horvat, B., Orbanic, A., and Sirok. B. (2015) Numerical Modeling of Dust Lifting from a Complex-Geometry Industrial Stockpile. Strojniski Vestnik-Journal of Mechanical Engineering 61: 621–31.

[5] Badr, T, and Harion. JL (2007) Effect of Aggregate Storage Piles Configuration on Dust Emissions. Atmospheric Environment 41, no. 2: 360–68. https://doi.org/10.1016/j.atmosenv.2006.07.038.

[6] Song, C., Peng, L., Cao, J., Mu, L., Bai, H.L., and Liu, X. (2014) Numerical Simulation of Airflow Structure and Dust Emissions behind Porous Fences Used to Shelter Open Storage Piles. Aerosol and Air Quality Research 14: 1584–92.

[7] Torno, S., Rodriguez, R., Allende, C and Torano. J. (2010) Dust Emission Reduction for Open Storage Mineral Piles by Fences: CFD Modelling.” In WIT Transactions on Ecology and the Environment, 136:121–28. https://doi.org/10.2495/AIR100111.