A new and efficient particle resuspension prediction model based on quasi-static moment equilibrium

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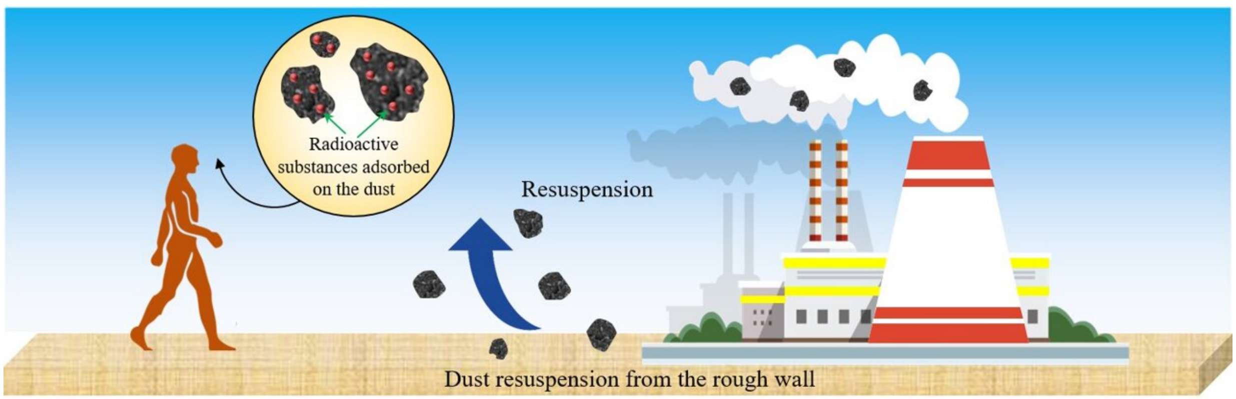

Dust binding radioactive substances produced in nuclear power plants diffuse to the environment due to resuspension, resulting in potential radioactive pollution. Credit: Qi Sun, Tsinghua University

A team of researchers explored the resuspension mechanism of deposited particles under the action of airflow. Using advanced image detection technology and numerical simulation method, a particle resuspension model based on quasi-static moment equilibrium was developed. The model takes into account the influence of flow characteristics, particle morphology, and rough wall surface, which improves the accuracy of the prediction of resuspension phenomenon, and can be applied to the traceability analysis of pollutants.

The team of Chinese researchers from Tsinghua University published their work in the journal *Particuology*.

Resuspension refers to the physical process by which particles deposited on a surface are entrained away through the action of a fluid flow. Particle resuspension is an important source of secondary environmental pollution. For example, dust particles carrying radioactive substances diffuse the atmosphere due to resuspension during nuclear reactor accidents; the dust deposited on the ground is inhaled by humans due to resuspension driven by vehicles.

In order to establish a more universal and physical resuspension model, the research team carried out lots of visualization experiments of particle resuspension using an atomic force microscope and high-speed camera to explore the effects of airflow velocity, particle size, and wall roughness on the resuspension process. Consistent with common knowledge, aerodynamic force, and adhesion force are the key forces that determine the resuspension of particles.

Therefore, with the increase of flow velocity and particle size, the resuspension fraction of particles increases. However, for the rough wall with low adhesion, it may produce a surprisingly low resuspension fraction, which is contrary to the common knowledge.

Peng Wei, an associate professor from Tsinghua University, said, "Through analyzing the motion of particles during the process of resuspension, we found that particles prefer rolling motion before detaching from the wall. Therefore, for micro-scale particles, the rupture of the equilibrium between the aerodynamic moment and adhesion moment on particles is the main reason for resuspension. For some rough walls with lower adhesion, it may produce a larger arm of force and then causes a larger adhesion moment to suppress particle resuspension."

The difficulty of resuspension model development is that the fluctuation of the near-wall flow and the rough wall are random. For this, the research team aims to establish a statistical resuspension model. Wherein, the rough wall morphology distribution is obtained and fitted by an optical profiler, and the flow fluctuation characteristic is calculated by the large eddy simulation method.

Based on moment equilibrium and probability distribution, a new and efficient particle resuspension prediction model is developed. Due to introducing of fluctuation characteristics and rough wall morphology, the model proposed by the research team is more accurate than the classical resuspension model.

"In the next step, our research team will focus on the influence of accelerated flow under variable conditions and the multilayer particle deposition structure on resuspension," said Peng. In this way, the researchers might apply the present model to more fields.

More information: Qi Sun et al, Experimental and mechanistic study of dispersed micrometer-sized particle resuspension in a square straight duct with rough walls, *Particuology* (2023). DOI: 10.1016/j.partic.2023.02.013

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