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Title: Collecting Mine Dust Particles with Liquid-Coated Vibrating Meshes, Phase 2

Organization: Virginia Tech

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Topic: Dust Control

Dust is an inherent byproduct of any mining activity. In particular, dust particulates less than 100 μm raise notable health and safety concerns. In coal mining, concentrated airborne dust can generate explosive mixtures that are easily ignited and self-propagating, and the inhalation of small, respirable dust particles can cause incurable lung diseases, including silicosis and coal worker's pneumoconiosis (so called black lung). Mine operators have typically employed preventative particle-collecting devices in underground mines to suppress airborne dust, and Mine Safety and Health Administration's (MSHA) 2014 respirable dust rule mandates even further reductions to respirable dust concentrations. In particular, the static panel filter, instrumental in most scrubber designs, is fundamentally limited in collection efficiencies and causes numerous operational challenges.

The flooded-bed scrubber has been developed and widely used for over 20 years as a preventative dust remover in continuous mining operations and has been recently tested on longwall shearers. Despite the proficiency of the scrubber, there are numerous technical challenges that limit the performance and efficiency of the flooded-bed scrubbers including a high clogging rate. In a prior proof-of-concept study, the project team investigated a new scrubber design that incorporates a vibrating functionalized mesh panel. Initially, a series of fundamental studies showed that this approach has the potential to reduce filter clogging, increase the uniformity of wetting, maintain high air flow rates, and enhance particle-liquid adhesion.

Based on these findings, a bench-scale, proof-of-concept scrubber unit was fabricated, and a series of tests were conducted based on a statistically designed experimental regime. Direct particle sampling and high-speed videography were used to analyze the scrubber performance, and the final results confirmed that the vibrating mesh scrubber unit was capable of capturing over 90% of the dust particles, a notable improvement over similar tests conducted with a simple static mesh. However, the results also show the importance of mesh frequency in achieving this optimal result. Some tests at non-optimal vibration frequencies and water flow rates underperformed those conducted with a simple static mesh.

The current project seeks to further develop this technology with the overall objective to validate the technical performance in a high-fidelity simulated mine environment. The first phase of the project will focus on further technology development, particularly with regard to particle clogging. Laboratory tests will be used to identify the optimal mesh configuration and vibrational characteristics that effectively shed dust particles from the filter. Pending success in these activities, the second phase of the project will include the design, construction, and validation of a full-scale vibrational scrubbing system. This unit will be tested at the NIOSH Dust Gallery in Pittsburgh, PA to fully quantify the performance gains and efficiency improvements associated with the proposed technology. All results will be incorporated into a multi-physics numerical model to further reduce scale up risk and support technology transfer activities.