

Grant AFC719-27: Control of Hazardous Gas Emissions to Longwall Face and Bleeder System: Laboratory Experiments, Modeling and Field Monitoring

Organization and Principal Investigator: Penn State University (Shimin Liu)

Focus Area: Health and Safety Interventions

Priority Area: Innovative Methods of Methane Detection Near the Face and De-energizing the Longwall Equipment

Problem Statement and Research Approach: Longwall mining presents a unique hazard in mining by both liberating a large methane gas flux and also providing a large high-impedance methane reservoir in the gob for its retention – a doubly hazardous outcome. Only a small fraction of the methane emitted into the mine ventilation system sources directly from the working face/freshly mined coal. The primary source of emission is from the gob, formed when the overlying strata collapse into the void created by longwall mining. Thus, the characterization of gob gas emission is one of the most challenging tasks due to the complexity of the gas flow behavior. Recent studies by the proposers indicate that the flow behavior in and above the gob area is a multi-mechanistic process, including sorption, diffusion, advection and non-Darcian flows.

The primary objectives of the proposed research are to develop appropriate strategies to characterize and model methane emission and transmission from the gob to the face and bleeder and to effectively mitigate impacts of elevated methane concentrations in the mine ventilation system. Initially, the flow behavior in the compacted gob zone will be characterized and modeled using both experimental and analytical investigations. This mechanistic model will then be applied to quantify and predict gas emission rates into the working face and bleeder. Following this, a numerical study of airflow dynamics around the working face and bleeder will be conducted. Mine site measurement and monitoring data will be used to validate the models. The knowledge gained through this research workflow will be transformative as it will provide a needed, new and mechanism-based understanding of fluid dynamics in the gob as well as airflow dynamics at the working face. Furthermore, it will yield a systematic strategy to evaluate gas emissions at the working face and to control methane concentrations in longwall underground coal mines.

Specific Aims: In order to achieve this objective, the following specific objectives are proposed:

- Determination of gob rock compaction processes and quantification of the flow behavior based on a granular mechanics-based approach.
- Development of analytical dynamic permeability/porosity evolution models for gob rocks based on rock compaction and in situ stress transfer from the collapsing overburden.
- Development of CFD numerical models using prior analytical models for porosity evolution as the constitutive governing equation coupled with the in situ stress profiles.
- Modeling of airflow dynamics at the working face and bleeder by CFD using the predicted methane influx as the emission source.
- Laboratory measurements of gas emission from gob to the face for different compacted gob rock materials and validation of the CFD models.
- Field measurement, monitoring, validation and upscaling of the developed models.