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Diesel Particulate Matter Exposure to an Operator of LHD Loader Working in an Active Ore Heading Area

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Extended Abstract

Underground mines are particularly hazardous environments where miners have exposure to toxic fumes and gases. To ensure mine safety a sufficient mine ventilation must be provided. Ventilation of underground mines should be estimated considering diesel equipment's engine power, blasting toxic fumes, gases, aerosols, dust and the unit airflow needed. Diesel engines are main sources of toxic gases (CO, CO_2, NOX, SO_2, hydrocarbons) and diesel particulate matter (DPM). DPM is related to elemental carbon (EC) and organic carbon (OC) and numerous gases and aerosols produced by incomplete combustion. Relationship between EC and OC fractions in untreated exhaust depends on engine operating conditions, engine type, fuel type, and a number of other parameters [5]. The total carbon (TC) is calculated by adding the EC and OC numbers together, and it typically represents 80% of the DPM [6]. Only 5-10% of all DPM are greater than one micrometer diameter [2]. Particulate Matter (PM_1) concentration is commonly thought to be used as a DPM level since it is the size range that encompasses practically all DPM [5]. Mine ventilation, diesel emission rate, exhaust flow direction, and drift face shape will influence DPM concentrations and dispersions. Mobile diesel equipment operators have the highest exposure to DPM. Main objective of this study is experimental sampling and analysis of DPM exposure to an operator of the diesel-powered load-haul-dump (LHD) loader working in an active ore heading area.

Experimental sampling of particulate matters (PMs) concentrations using a RigzardPM Plus sampling instrument has been conducted in the underground polymetallic mine. This sampling was conducted within 12 minutes in the operator open cabin of the mine face LHD loader R1700 (engine model Cat@C11 ACERT, 241 kW, Tier 3/Stage IIIA Equivalent Engine) working in the active ore heading area.

As a result, the average PM_1 concentration obtained from the RigzardPM Plus indicated 655 $\mu g/m^3$ at the mine ventilation air velocity of 0.7 m/s. LHD loader operated for 30 meters haulage distance and spent about 2 minutes per cycle time. According to the correlation between TC and PM_1 (DMP) introduced by the NIOSH 5040 method, the obtained concentration of 185 $\mu g/m^3$ was very close to the Mine Safety and Health Administration (MSHA, 2008) DPM limit value of 160 $\mu g/m^3$, which is measured by TC. Thus the auxiliary ventilation needs to have insignificant improvements to supply sufficient dilution of toxic fumes in the active ore heading area.

Received measurement results look very reliable and demonstrate suitability of the RigzardPM Plus air sampling instrument for monitoring DPM concentration with its further validation for computational fluid dynamic (CFD) modelling of DPM distributions in underground developments. CFD simulation will consider LHD loader positions and auxiliary ventilation sets for auxiliary ventilation of the active ore heading area. Expected outcomes of this further work are to improve the mine auxiliary ventilation and protect mineworkers' health.

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