Mining Emissions/Control Technologies

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Overview

- Donaldson's background
- Emissions overview
- Emissions technologies for underground mines
 - Current
 - Options for the future



Donaldson at a glance

- Founded in 1915
- Global company with 14,000+ employees in 37 countries
- Diversified product range, focused on filtration
- Since 1950's manufacturing mufflers
- Exhaust aftertreatment for Heavy Duty Diesel market since 1990
- Developed the first underground exhaust filter with the Bureau of Mines in 1991





Frank Donaldson's first air cleaner design





Image from Donaldson bulletin #50-341

Emissions Overview



Image from https://www.perfectfuel.ca/understanding-clean-green-fuel/

Emissions Overview

- Diesel Oxidation Catalyst (DOC)
 - Oxidizes: particulate matter (PM), CO, and Hydrocarbons
 - Flow through substrate
 - 15-20% PM reduction



Flow through substrate

- Diesel Particulate Filter (DPF)
 - Traps PM, then burns it off (regenerates), leaving only ash
 - Regeneration can be active (added heat) or passive
 - Wall flow substrate
 - 85-90+% reduction in tailpipe PM

- Selective Catalytic Reduction (SCR)
 - Requires injection of Diesel Exhaust Fluid (DEF = 32% Urea)
 - Converts urea to ammonia (NH3) so NOx can be reduced on the SCR
 - Flow through or wall flow substrate
 - 80-99+% reduction in tailpipe NOx



Current Mining Emissions Technology

Used in permissible <u>and</u> non-permissible applications

Dry Scrubber

- Description: Uses a shell and tube heat exchanger to cool exhaust gas before collecting soot on a disposable exhaust filter
- Requirements: Heat exchanger and filter housing
- Pros:
 - Low surface and exhaust temperature
 - Permissible
- Cons:
 - High cooling load on engine
 - Maintenance: cleaning heat exchanger
 - Replacing exhaust filter
 - High cost
- Barriers: None





Wet Scrubber

- Description: Uses a water bath to cool exhaust gas before collecting soot on a disposable exhaust filter
- Requirements: Scrubber housing

• Pros:

- Low surface and exhaust temperature
- Cons:
 - Maintenance: Refill water tank and clean scrubber housing
 - Weight of water housing
 - Wet sludge is produced
 - Humidity and water affects filter life
 - Replacing exhaust filter
 - High cost
- Barriers: None



Image from

https://www.researchgate.net/publication/328678284_Underground_Diesel_Exhaust_Wet_Scrubbers_Current_Status_and_Future_ Prospects



Options for the Future

Used in non-permissible applications Modifications required for permissible applications

Passive Regenerated Ceramic Filters (DOC and DPF)

- Description: DOC and DPF system that runs at elevated temperatures to regenerate.
- Requirements:
 - Typical full load exhaust temperatures are up to 600°C (1112°F)
 - Sensors: Temperature and delta pressure
 - Electronically controlled engine
- Pros:
 - Lower operating costs than wet or dry scrubber.
 - High PM and HC reduction no break in period
 - No downtime for regeneration
- Cons:
 - Exhaust gas is not cooled
 - Requires high duty cycle (hot exhaust to clean filter)
 - May require filter removal if regeneration is not adequate
 - Ceramics are fragile
 - Potential for NO2 production
- Barriers:
 - Surface temperature of components
 - Electronics (Permissible locations)





Image from https://www.deere.com/en/campaigns/engines-and-drivetrain/diesel-engine-technology/

Active Regenerated Ceramic Filters (DOC/DPF)

- Description: DOC and DPF system that increases temperatures at set limits (time or backpressure) to regenerate.
- Requirements:
 - Electronically controlled engine
 - Requires either fuel injection into exhaust or electrical heater for regeneration.
 - Sensors: Temperature and delta pressure
- Pros:
 - Very high PM and HC reduction
 - Can control when regeneration will occur (i.e. outside of mine)
 - Lower operating costs than wet or dry scrubber.
- Cons:
 - Exhaust gas is not cooled
 - Additional energy in exhaust for regeneration
 - Down time for stationary regeneration
 - Ceramics are fragile
 - Potential for NO2 production
- Barriers:
 - Surface temperature of components
 - Electronics (Permissible locations)

Image from https://www.deere.com/en/campaigns/engines-and-drivetrain/diesel-engine-technology/





Active Regenerated Ceramic Filters (DOC/DPF/SCR)

- Description: DOC, DPF and SCR system that increases temperatures at set limits (time or backpressure) to regenerate.
- Requirements:
 - Electronically controlled engine
 - Sensors: Temperature, delta pressure, NOx
 - DEF (Urea) tank, pump, injector, mixer, SCR
- Pros:
 - Very high PM, HC and NOx reduction
 - Can control when regeneration will occur (i.e. outside of mine)
 - Lower operating costs than wet or dry scrubber.
- Cons:
 - Exhaust gas is not cooled
 - Additional components and need to refill DEF tank
 - DEF will freeze at -11°C (12°F)
 - Poor mixing or low temperatures can form DEF deposits in tailpipe
 - Potential for ammonia in exhaust
 - More expensive than DOC/DPF
 - Ceramics are fragile
 - Potential for NO2 production
- Barriers:
 - Surface temperature of components
 - Electronics (Permissible locations)

Image from https://www.deere.com/en/campaigns/engines-and-drivetrain/diesel-engine-technology/





Questions for Industry

- To improve wet and dry scrubber filters design:
 - What is a typical duty cycle of the equipment?
 - What are your targets for:
 - Life (replacement interval)
 - Operation cost
 - Efficiency
 - Permissible or non-permissible location
 - Are there special requirements?
- To implement new technology
 - Retrofit existing or new engine?
 - Surface and exhaust temperature requirements?
 - 30 CFR
 - Are there special requirements?
 - Low sulfur fuel at mines?
 - Permissible or non-permissible location?



Summary

- Donaldson developed the initial underground exhaust filters.
- Improvements to existing dry and wet scrubbers can be made but we need feedback on the targets customers want.
- Higher PM and NOx efficiency are available for mining applications using Tier 4/Stage 5 aftertreatment technology.
 - Clear customer specifications and requirements are needed to correctly implement this technology underground.
 - Certain applications will require additional changes (and validation) for underground mines.



THANK YOU

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