

Observations of a Consulting Mine Ventilation Engineer

By:

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Background

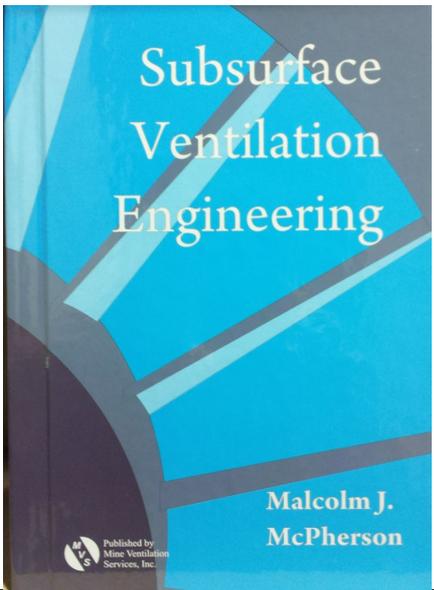
In my 35 years as a mine ventilation engineer, I have made several observations:

1. Engineers knowledge (skill) in ventilation is quite variable
2. Engineering design has become easier with software advances
3. Engineers are relying on the ease of design tools rather than independent or first principal assessment
4. Technology advances in ventilation system management and equipment will impact the future of the field.

Fundamentals

Engineers around the world have very different abilities in mine ventilation.

- Largely dependent on education and experience
- Ventilation planning is much easier with new software but this requires the engineer to be more aware of data used in the analysis and the calculation schemes used by the design tools



Mine Ventilation At Mines



I have noticed that in many parts of the world mine ventilation is a discipline that is used as a “stepping stone” in a mine engineer’s career and not a career in itself. It often falls on an entry level engineer.



Additionally, many university mine engineering curriculums only require a single class in mine ventilation – hardly adequate for a practicing ventilation engineer.



The exception can be where legislation requires a ventilation officer or the system is large and complex and requires a full time person.

Mine Ventilation Engineering



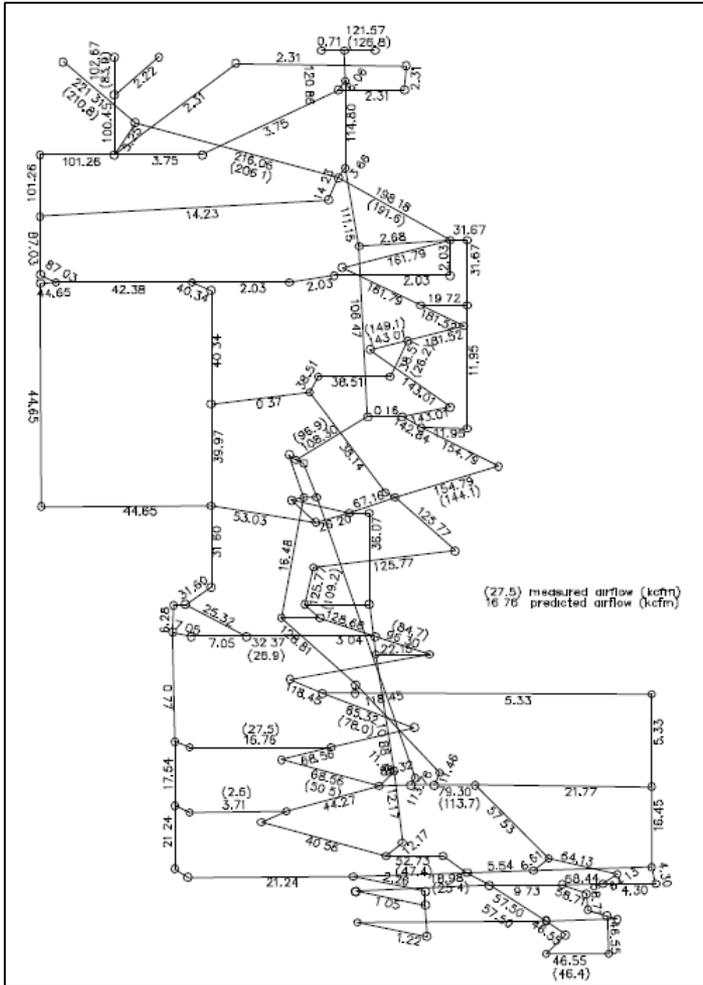
Because of the differences in skill, desire and experience, ventilation engineering abilities can vary significantly.



Add to that the ease of using ventilation software tools, and designs can be created without “thinking” if the answer is correct or not.

The use of tools can create “pretty designs and answers” but are they true and realistic?

Ventilation Design Software



When I started mine ventilation engineering using computers it was through main frame computers with no output graphics

Graphics were hand drawn onto schematics that rarely looked like the mine

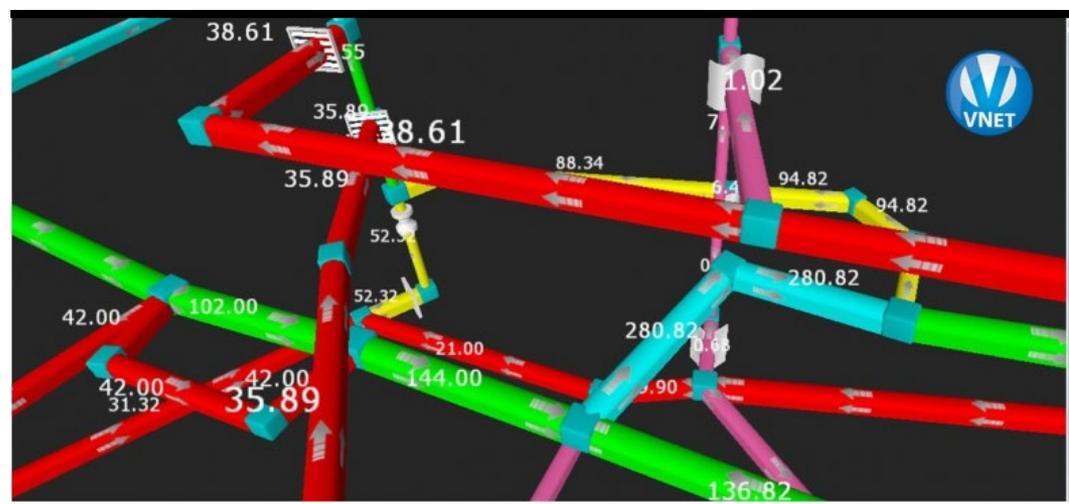
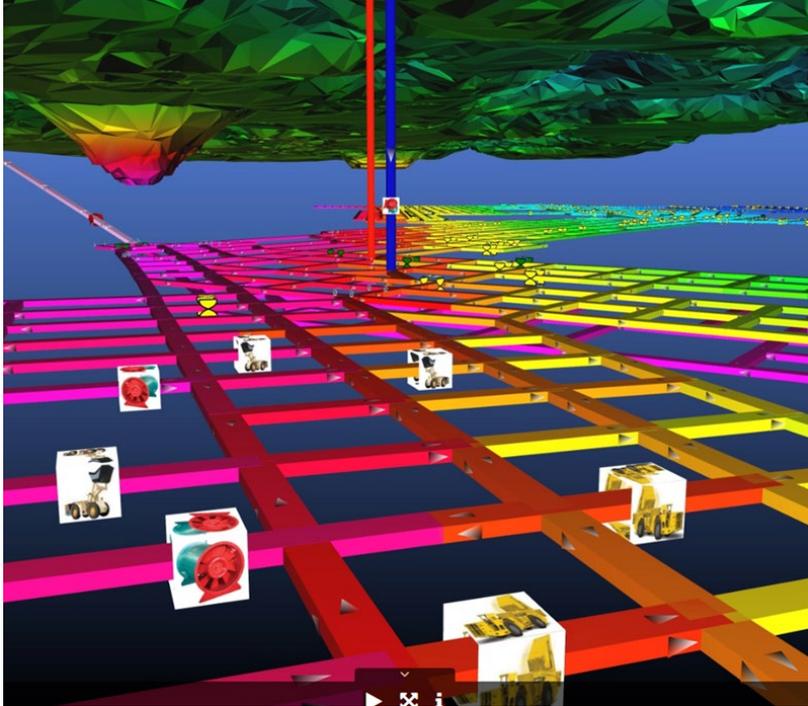
Because it was costly to run models, the engineer really thought through the model input before running the simulations

Ventilation Design Software

Today, software has evolved significantly

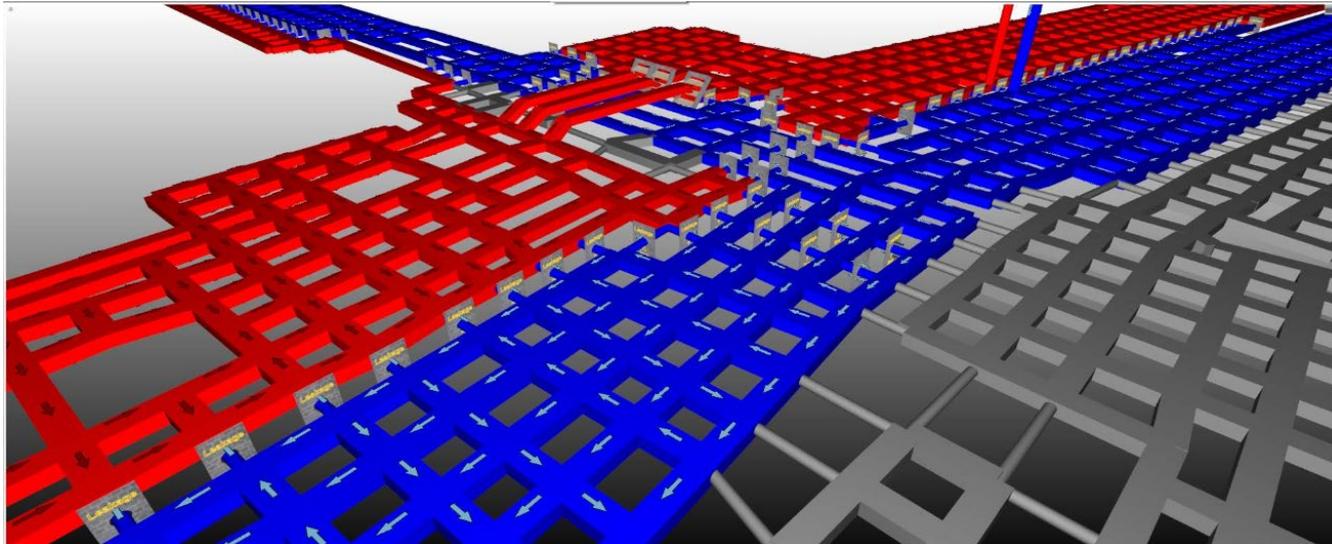
An engineer with limited ventilation experience or education can literally set up a model in a few hours

- The models will import information from mine planning software and will “look” exactly like the actual mine
- The graphics are outstanding, showing moving air, fans, topography, etc.
- The user can enter global resistance values to rapidly populate the model
- Fans are input on curves based on manufacturer provided data

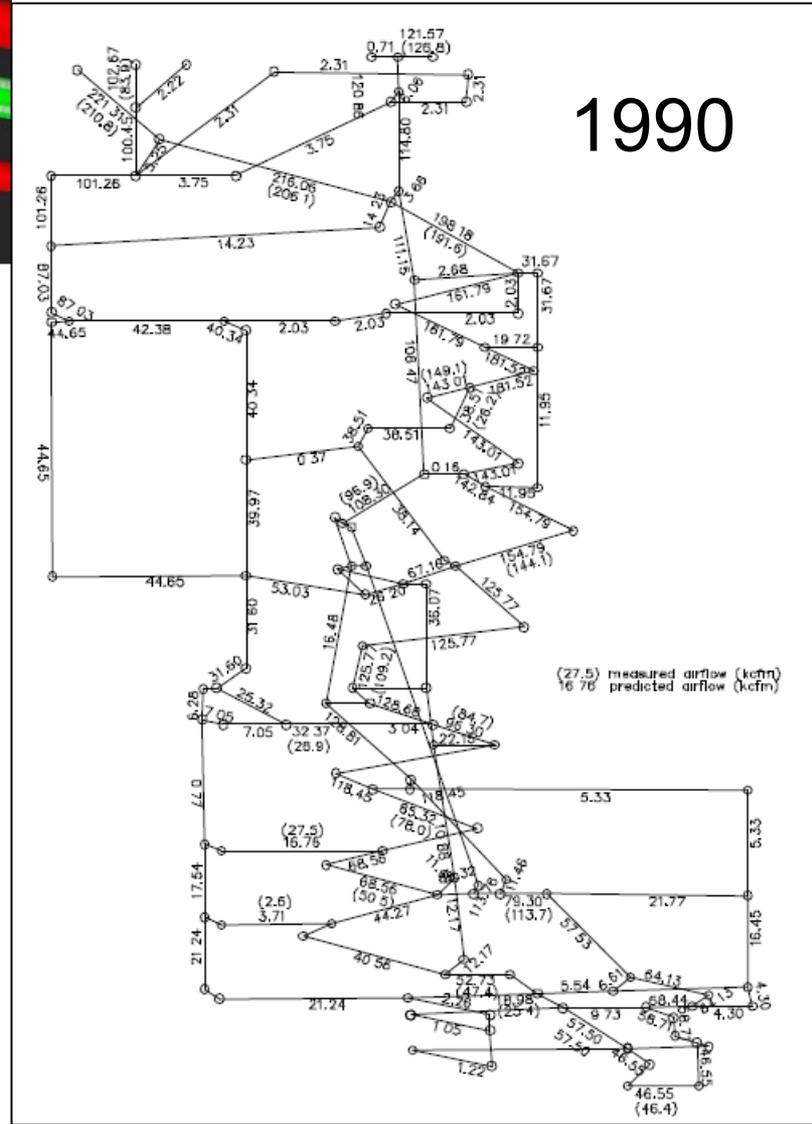
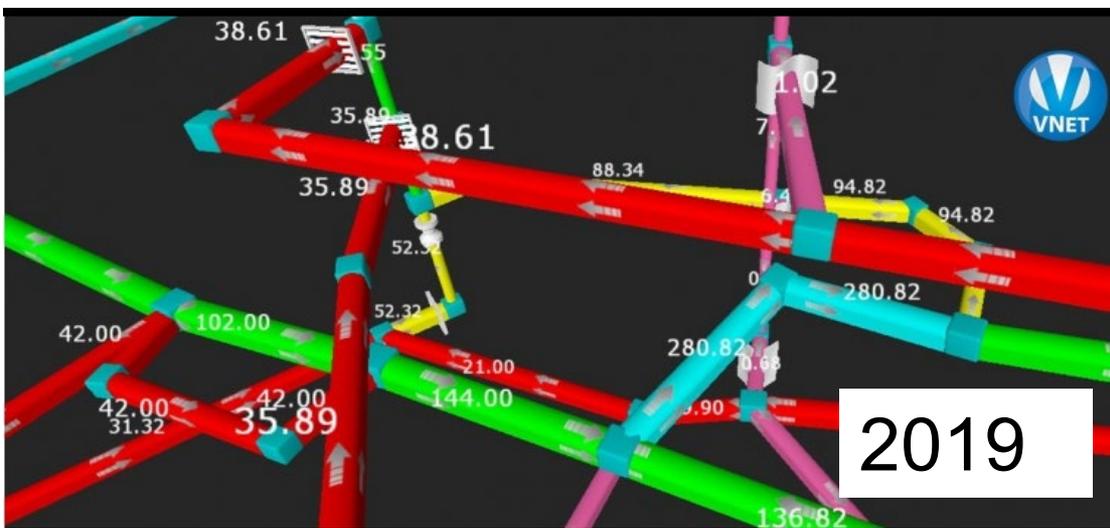


www.na.srk.com/en/our-services/mine-ventilation-main1/mvs-ventilation-software/na-vnet-0

From: www.ventsim.com



<https://www.vuma3d.com/gallery/>



The Difference is
VERY
NOTICEABLE

Ventilation Design Software

My caution is that ventilation software is only a sophisticated calculator. It is nothing more.

- **Input poor data and you will get non-sensible results**



I am seeing far more models today that are not making sense because the user likely has a limited understanding of ventilation fundamentals

Ventilation Design Software

Do new engineers know how to arrive at resistance values from first principals?

One area of concern is using default values in the software can give misleading results. Most software allows the user to default friction factors, bulkhead or stopping resistance values, and other parameters.

Other than a number, do they know what they represent?

- It is up to the **USER or Engineer** to understand if these default values are accurate – Incorrectly applying these values can lead to significant errors.



Ventilation Software Use



In more and more models that I review, I observe users inputting a resistance value for bulkheads or stoppings that equates to infinite resistance (a total closure of the drift from air).



In reality, a zero leakage bulkhead is rarely the case. I have seen this used in a model where the bulkhead with a door actually had 4 m³/s leaking through holes. The model had zero leakage. Multiply this by a number of bulkheads in the mine, and your model becomes far less accurate.

Ventilation Software Use

The software is not the issue. The user needs to be aware of any default value offered in the software. It is up to the engineer to decide what values are applicable to their specific mine. However, in an attempt to make software easier to use, developers may be contributing to this issue.

I interpret much of this to a lack of understanding between the engineer and the tool and the desire to develop a model quickly.



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Ventilation Observations

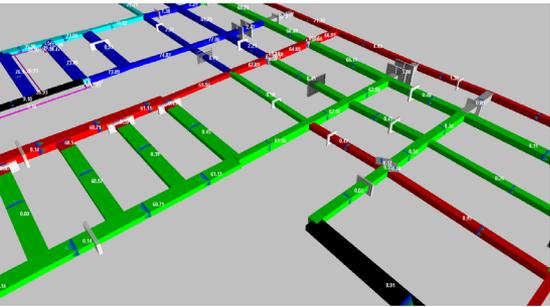
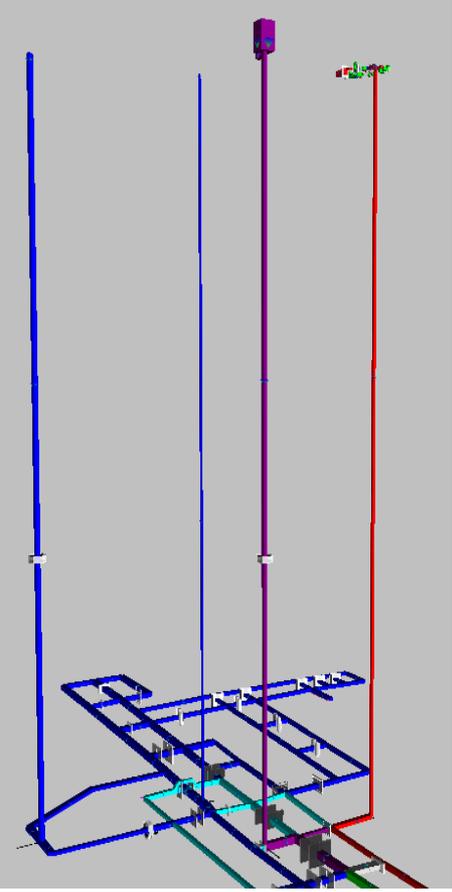


There can be a significant difference between the manufacturers curves and the system fan installation

- To the practicing ventilation engineer, using measured data from the mine is fundamentally understood.
- However, I am constantly amazed when I visit an operating mine and the engineer presents a model without a single measured value in it, including fans or friction factors. The model is entirely set up by textbook friction factors and often without even shock losses.
- I am also seeing many models that have the fan operating on an assumed curve (as provided by the manufacturer). In reality, the measured fan operating point should be included in the model.
- Only by surveying the mine can you determine leakage paths and system problems (e.g. a leaking bulkhead/stoppings, gob area or open ore pass).

Ventilation Observations

- Engineers today seem enthralled with running models that look very good. This is a powerful way to present a future projection to management, but can be fraught with errors.
- Given the high capital cost of ventilation infrastructure (e.g. raises, cooling or heating systems, etc.), not having an accurate model can have costly consequences.
- Again, this I contribute to
 - A lack of skill/knowledge at some mines in the field of mine ventilation
 - Ease of setting up models that are not necessarily accurate but are graphically impressive (becomes easier to sell to management).

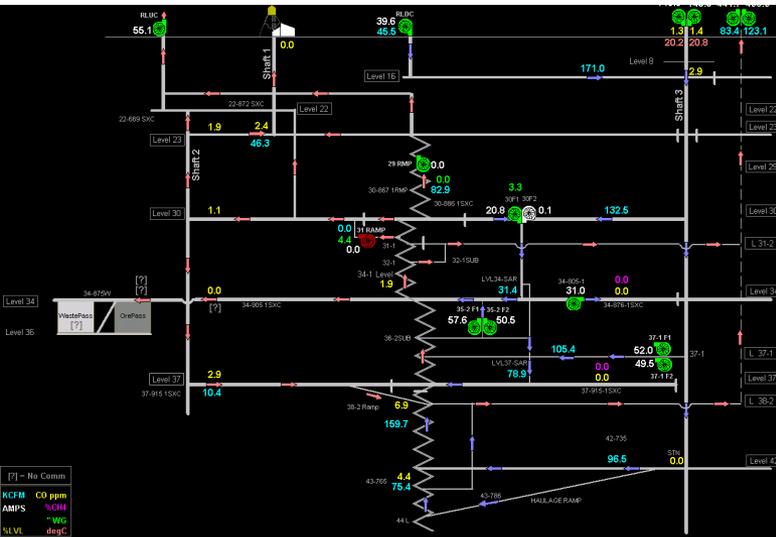


Future of Mine Ventilation

The future of mine ventilation will include some components in automating fans and regulators but will also be impacted by automation and electrification of underground equipment.

Future of Mine Ventilation

- Over the past decade or so, automation of mine ventilation systems has been developed.
- This technology is based on saving operating costs by applying ventilation to only where it is needed in the mine.
 - Tagging equipment and personnel so ventilation can be applied to a specific area.
 - Fans on variable speed drives
 - Automatic adjustable regulators
 - Extensive monitoring of gas, flow, temperature and other parameters.



Ventilation Automation

- Savings in lower ventilation, cooling or heating requirements can be very beneficial.
- However, VOD will only make sense to mine operators if the operating and maintenance costs (communication, sensor reliability and calibration, etc.) are reasonable.
- Many mines implement a manual or limited system (e.g. manually turning down fans in areas, etc.)



Ventilation Automation

- With VOD, what do the mine ventilation planners design to? The conservative approach would be to procure fans capable of full ventilation needs.
 - However, if designs were based on a reduced flow there could be significant savings in capital costs for infrastructure (shafts, fans, cooling plant, air heaters, etc.)
 - VOD systems would have to be well proven for companies to gamble on installing infrastructure based on a lower flow to support the mine.
- Will this system be the wave of the future? For me the jury is still out.

Future of Mining and the Impact on Mine Ventilation

- Companies are funding major research dollars into electrification of underground mobile mining equipment and removing operators from the underground.
- Artisan Vehicles (now part of Sandvik), Sandvik, Atlas Copco, Caterpillar and Komatsu Mining, are some of the companies that have developed or have an interest in developing fully electric underground equipment.
- The use of electric equipment will not remove but will reduce the ventilation requirement significantly in metal mines.

Electric Mining Equipment

- Electric vehicles will offer a significant benefit in removing diesel exhaust and DPM emissions compared to diesel machines.
- These vehicles will give off less heat which can be a major benefit in hot mines (reducing any refrigeration requirements)
- Technology is improving rapidly in this field.
- The impact of this technology will be interesting from a ventilation perspective since the only pollutants may be heat and dust (provided the mine is non-gassy) and will drastically change the way we design future ventilation systems.

Calculating Airflow for a Diesel Fleet

Fleet Type	Equipment Model	Engine Rating (kW)	No.	Availability	Utilisation	Flow required per unit @ peak usage	Operating fleet average m ³ /sec
LHD	Caterpillar 2900	305	5	85%	65%	18.3	50.6
Truck	Caterpillar AD55B	439	4	85%	65%	26.3	58.2
Twin Boom jumbo	Sandvik Axera 7	110	2	85%	15%	6.6	1.7
Longhole drill	Sandvik DL411	110	2	85%	10%	6.6	1.1
Light vehicles	Toyota Landcruiser V8	151	6	85%	20%	9.1	9.2
Mine Grader	CAT12H	133	1	85%	60%	8.0	4.1
Service IT's	CAT930K	115	3	85%	70%	6.9	12.3
Explosives truck	Normet Charmec	96	1	85%	50%	5.8	2.4
Leakage						10%	14.0
Contingency						10%	14.0
Total							167.6

Example flow based on 0.06 m³/s/kW diesel

Electric Mining Vehicles

Artisan Vehicles (now Sandvik) 40-ton haul truck



Caterpillar R1700 Loader



Autonomous Mining

- In autonomous mining, the workers operate the mining equipment remotely or the equipment operates with artificial intelligence



Remotely Operated LHDs

Autonomous Mining



- CODELCO Chuquicamata Division is planning on a fully automated, autonomous fleet for the new underground mine (from Sandvik)
- CODELCO is also purchasing hybrid equipment for its mines

Autonomous Mining

- In this situation, what is the flow requirement for where the remote equipment operates?
- Would electric vehicles make sense in this option given that diesel equipment could operate without the health concerns related to personnel?
- Do governmental legislated requirements for airflow/equipment (e.g. $\text{m}^3/\text{s}/\text{kW}$) power make sense? Why require a flow when no one is exposed to the diesel emissions?
- Can we allow lower airflows that will result in higher contaminants (e.g. dust, diesel particulate matter, gas, etc.) provided the equipment operates effectively?
 - Do we re-establish ventilation for personnel re-entry?



Future of Mine Ventilation

- Mining companies will push for more autonomous operation of equipment and removal of personnel from the underground
 - For cost benefits (reduced labor costs and more time operating equipment)
 - For safety
- How will this effect the future of mine ventilation?
 - If the flow requirements are significantly reduced, does VOD contribute to the new designs?

Summary

- Ventilation engineers need to be more cognizant of the models they develop.
- Ventilation software is a tool to an end. Understanding the process is vital to an accurate model.
- Ventilation models are more than strictly k-factors for an existing mine. Fundamentals need to be followed: Surveys, data reduction and model development.
 - Models are only as good as the data input.

Summary

- Electric equipment and automation will significantly impact future ventilation designs, likely resulting in much lower ventilation needs.
- How will this impact legislative regulations (e.g. flow per diesel kW)?
- VOD can optimize ventilation systems and reduce operating costs; However, with electrification/automation and the corresponding reduction of ventilation will VOD be an effective investment?

Thank you!

