VENTILATION ON DEMANDS EFFEKT PÅ ENERGIBESPARING OCH FÖR KONTROLL AV LUFTKVALITET I SERRA GRANDE GRUVAN, BRASILIEN

Impact on energy consumption and air quality control with ventilation on demand in Serra Grande mine, Brazil

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Summary

It is well known that the energy cost for ventilation in mines is a big part of the total energy cost there and in the construction industry the situation is similar. That is the reason for the concept Ventilation on Demand (VoD) has been developed. In this particular case the product Serpent Automatic intends to be a customized option for the single fan, single heading, with focus on energy saving and environmental control.

In the market we have several options of VoD controlling the complete mine, however there are few products available for controlling the ventilation at the single face scale. Epiroc is the first company in AngloGold Ashanti– Serra Grande in Brazil to perform a trial and to do so in one single fan/single heading.

By using gas sensors to detect CO and NO2, we are able to measure the concentration of blasting gases mainly, but also to have a better control of the environment during, for example, critical activities as mucking.

This paper describes the system, the impact on energy consumption and experiences learned during the implementation in AngloGold Ashanti– Serra Grande in Brazil.

1. Introduction

An underground ventilation system requires electricity to operate the fan, refrigeration system to cool the air in the mine or a heating system in winter. This accounts for a significant proportion of a mine's energy consumption and costs. Recent studies have shown that the ventilation systems in highly mechanized metal mines could be responsible for 40–60% of the mines' energy consumption [1]. In AngloGold Ashanti – Serra Grande Mine, energy costs represent 7% of the total production costs. Energy costs are the third largest production cost at AngloGold Ashanti Brazil. At Sierra Grande Mine they make significant effort to control its operating costs, especially in ventilation, since the largest investment they are delaying is the installation of a refrigeration plant, meaning a huge increase in energy demand. Serpent Automatic is presented as an option to meet this challenge.

2. Background

2.1. AngloGold Ashanti– Sierra Grande Mine in Brazil

AngloGold Ashanti, headquartered in Johannesburg, South Africa, is a global gold company with a portfolio of long-life, relatively low-cost assets and differing orebody types in key gold producing regions. The company's 14 operations are located in 9 countries (Argentina, Australia, Brazil, Ghana, Guinea, Mali, the Democratic Republic of the Congo, South Africa, and Tanzania) and are supported by extensive exploration activities, including a greenfields exploration program in Colombia, the tenth country in which it has a presence. Currently, AngloGold Ashanti is the third largest gold producing mining company in the world.

Serra Grande Mine, wholly owned by AngloGold Ashanti, is located in central Brazil in the state of Goiás, about 5 km from the city of Crixás. It comprises three mechanized underground mines – Mina III, Mina Nova and Mina Palmeiras – as well as an open pit. One dedicated metallurgical plant treats all ore mined. Annual plant capacity is 1.5 Mt.

2.2. Ventilation in Serra Grande

The purpose of ventilation in underground operations is to generate and maintain a good and healthy working environment, free from contaminants or at an acceptable level. Serra Grande has 11 primary fans and an additional 22 secondary fans. Each installation is provided with a Variable Frequency Driver (VFD) controlled and monitored from the surface. The dampers to adjust airflow and temperature inside the mine are also controlled from the surface. However, no controls have been carried out to adjust the ventilation automatically through monitoring the air quality. Epiroc is the first company in

AngloGold Ashanti – Serra Grande Mine to conduct a trial and to do so in one single heading and on one single fan.

2.3. Serpent Automatic System (VoD)

In response to the current pattern of excellence in operation for companies in both mining and construction, and particularly in consideration of the intense development of mines and tunnels, Epiroc has created a special ventilation system on demand. This system, designed for tunnel operations, with a fan station for a single heading, is called the Serpent Automatic System (henceforth referred to as VoD). The tests were conducted at Serra Grande Mine in Brazil to verify its correct operation and purpose.

2.4. Description of the VoD System

It is a simple yet effective system. The tunnel or drift is a single heading and the VoD is then connected to a single fan station. The system is connected to the WiFi operating system.

It has been designed with two sensors placed on a trolley located close to the tunnel heading: one sensor for CO and one sensor for NO2 emissions.
In the underground mine, the system is required to dilute and remove contaminants generated by mining and construction operations in order to provide adequate working conditions for workers and equipment.

These sensors have been selected mainly because loading and hauling activities contaminate the air and gases from blasting – Carbon oxide (CO) and Nitrogen dioxide (NO2). These gases constitute two of the most dangerous gases and make it essential to monitor these emissions.

The fan speed levels can be actively controlled by the system, measuring the levels of CO and NO2 gases in the tunnel. The fan speed can be reduced as soon as the sensors detect a reduction in these gases in the tunnel or drift. In contrast, if loading and hauling activities or blasting activities cause an increase, the VoD system adjusts the fan speed until it counteracts it.

The sensors on the trolley continuously monitor gas levels in the tunnel and transmit the data via the wireless network to the rest of the system. The levels are processed and evaluated in the control unit and, consequently, the fan speed is controlled by the frequency inverter. It is possible to obtain a backlog of all the events and download it in order to process it.

2.5. *Serpent Automatic System components*

- **Sensor unit:** Located on the trolley. The unit is designed to enter the tunnel or the mine development in advance. The trolley contains the sensors for detection and measurement of CO and NO2. It also contains an override button, allowing override of the current system mode and a temporary increase in ventilation. This unit must be connected to the power source. In the event of any power outage, it has a battery with a two-hour capacity.

- **Control unit:** "The master". This interface unit connects the ventilation system, according to demand, with the frequency inverter, as well as controlling the fan. It is in this unit that all control signals are exchanged between the system and the frequency inverter. This control unit is mounted on the wall or cabinet close to the frequency inverter.

- **Operator Unit:** this third component system is the interface between our system and the user. This is the system from where the operator controls and can make changes in the system when necessary. The panel shows the current status and histogram, for instance, fan status and gas levels. This panel can be located in a remote control room, if preferable.

Figur 2-1 Komponenter i Serpent Automatic systemet (VoD)

The fan unit has been modified for variable speed operation, according to operational requirements, with the ability to control the operation in three ways.

- **Automatic Control:** this is the way in which the system has been designed, as well as a consequence of the continuous monitoring of the sensors that adjust the fan speed. If, by chance, something occurs whereby the system is disconnected or fails, the fan unit will continue to function follow its functions at 100% of its speed without affecting safety in the work area.

- **Manual Control:** this mode does not use the sensor data to adjust the speed of the fan. Instead, the speed is selected by the operator using a slide control slider on the operator panel. Speed can be selected from 10% to 100%.

- **Control Overrun** "Overrider": This allows you to temporarily activate or deactivate the overdrawing mode of overdrawing. The time starts from the moment the button is activated and, once the time has elapsed, the system returns to its previous state. The time can be configured from 0 to 600 minutes.

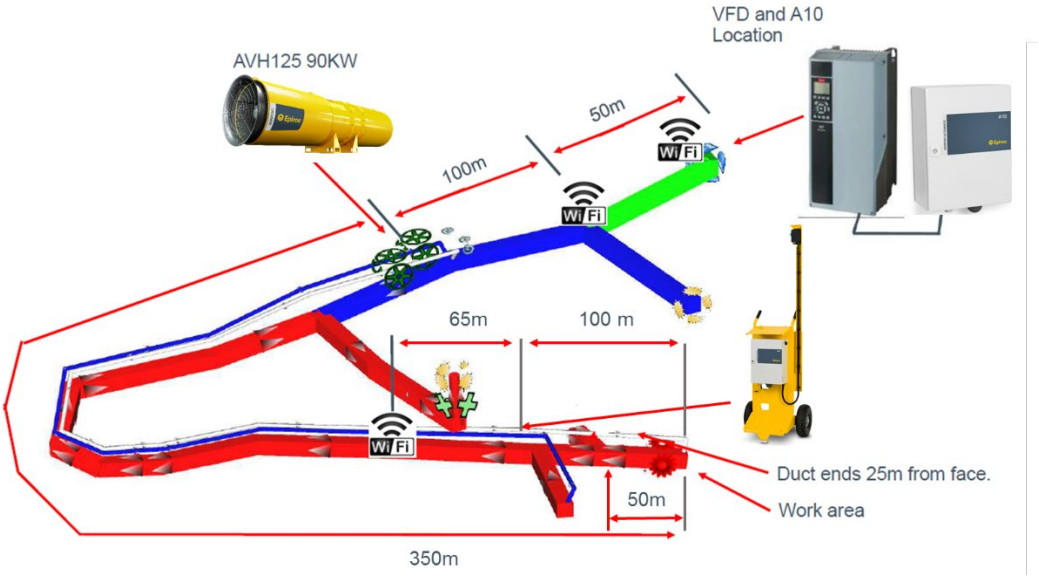
3. The trial

The motivation for the trial was to reduce energy consumption inside the mine. The trial focused on cost reduction by reducing the power consumption required to ventilate the area (maintaining air quality in accordance with the regulations). Assertive control and energy savings are priorities for safety and efficiency. AngloGold Ashanti as a group has one project to reduce operating costs to USD 800 per ounce (called OE800) – so any measure aimed at reducing costs is very attractive. Another point is that AngloGold Ashanti in Brazil has an internal committee called CIRE ("Comissão Interna de Racionalização de Energia") for energy efficiency that gathers several measures related to reducing energy consumption.

3.1. Test setup

The test was conducted in one development drift that depended on ventilation from one fan station that was controlled by the VoD. The drift was in the Inga Ramp (Orebody IX) at a depth of around 750 meters from the surface, developed by a contractor and subsequently to be operated by the mine. It was a six-month trial, with monthly meetings and follow up on necessary measures during the test.

The fan used for the development drift, to which the Ventilation on demand was going to be installed, is model Serpent AVH125.90: a fan 1.25m diameter and a 90kW engine with a Danfoss_VLT Aqua Drive frequency inverter to control the speed. All network communication was via the existing mine infrastructure (VLAN241 was only used for Epiroc equipment).



Figur 3-1 Skiss av VoD placeringen i orten

3.2. Limits setup

All mines in Brazil must comply with the NR-22 standard [3] ("Norma Regulativa 22" established by the Brazilian government – specific topic related to regulations and standards for mine operation). Limits were set in the beginning of the trial.

NO2	< 4 ppm
CO	< 39 ppm
CO2	<3900 ppm
Temperature	30 degrees
Noise level	<85 dB

Tabell 3-1. Gränsvärden satta vid försökets början

For AngloGold Ashanti – Serra Grande Mine, the possibility of monitoring and controlling the air temperature in the drift was a critical point. Even though the VoD system installed in Brazil has no temperature measurement, separate temperature sensors were used in order to correlate with the installed system.

4. Implementation of the trail

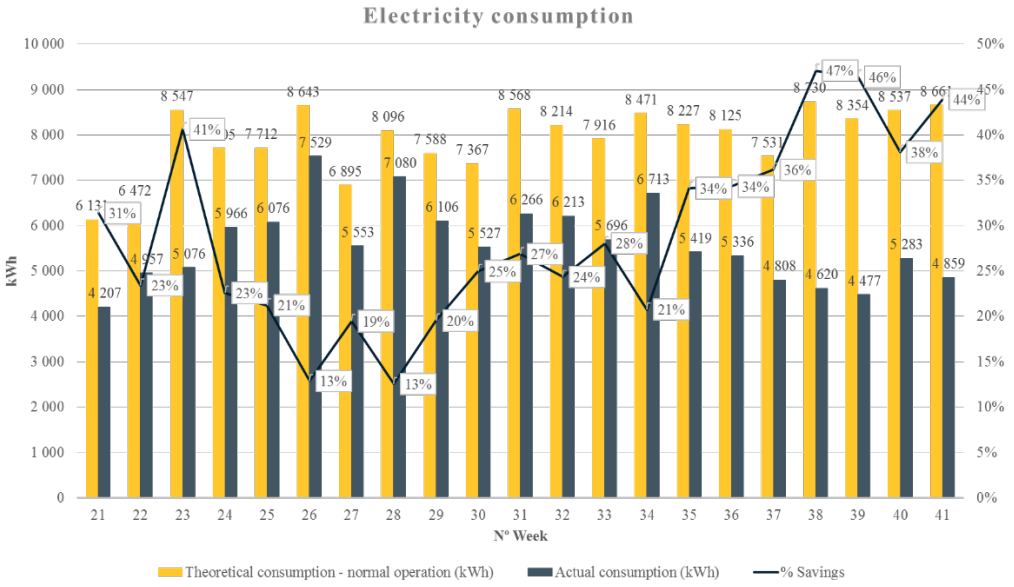
One of the initial challenges was to find a good location for the sensor unit, where the empirical recommendation is 50 m. However, differences were observed in the field and the location was adjusted three times. Three different sensor unit locations, 50 m 100 m and 115 m from the heading, were evaluated during the trail. In conjunction with the measurement of the signal, the location of the sensor unit was determined, approximately 90 meters from the end of the ducting and 115 meters from the face.

The system has been built in automatic mode. However, during the period of analysis, the level of manual mode operation of VoD was significant. During the entire trial the level of operation in manual mode oscillated, affecting the benefits of using the VoD system.

5. Results

In the data from the trial it is possible to observe the impact on energy costs. The worst weeks only a 13% reduction in power consumption was achieved due to the type of running: 50% automatic operation mode and 50% manual operation mode. 10 weeks later a 47% reduction in power consumption was noticed, when 98% was run in automatic operation mode.

The results from the six-month trial in the Serra Grande Mine in Brazil shows that good results can be achieved when operating in automatic mode. This demonstrates the importance of understanding the system through training and good communication with all users.



Figur 5-1 Verklig jämfört med teoretisk elektrisk konsumtion under försöksperioden

6. Conclusion and recommendations

This paper about a case study of a customized Ventilation on demand system tested over a period of six months in a gold mine in Brazil shows that to achieve good results an automatic mode operation is required and that this can be achieved through training and a correct way of communicating with the operators.

An important advantage of the system was to monitor the levels of CO, NO2, SO2 and the temperature as an input for air quality control. The trial also showed a reduction of energy consumption when adapting the ventilation with the VoD system.

The Serpent Automatic system provides a simple way of measuring and monitoring air supply. This information can be used for reports, tracking or analyzing of the effectiveness of the ventilation system.

To extract the maximum benefit from this system it is recommended that a dedicated person on the ventilation crew follows up, measures and collects information using the same method that was adopted in the trial.

There is another benefit by using the VoD system in tunnels or drifts where the size of the ventilation normally is selected based for the entire length. The operator does not have to manually adjust the speed of the ventilation when running the customized VoD system. The system does this automatically- consequently reducing costs and monitoring the air quality.

7. References

[1] New ventilation design criteria for underground metal mines based upon the “life-cycle” airflow demand schedule, Karoly-Charles Kocsis. The University of British Columbia. Vancouver, Canada 2009

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[3] Norma Regulativa 22,
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