The mining sector was selected as it is one of the largest electricity consumers in South Africa. A substantial amount of energy is used to de-water the mining shafts of fissure and service water. Improved load management will result from automating the de-watering system. Load management makes it possible to reduce energy usage during the Eskom peak periods. This will result in financial savings for the mine, while creating the climate for a more reliable supply of electricity from Eskom.

On ultra deep gold mines the de-watering system is used in a cascaded manner to transfer water from one reservoir to another until it ultimately reaches the surface holding area. Previously, water pumping systems would pump water out of the underground dam or reservoir when downstream dams were able to accommodate the inflow. This manually controlled, simplified pumping system will not allow for improved load management using only local underground system control. By automating the process the control can be centralised, enabling load management, while considering all constraints of the system.

Site identification

A typical mine de-watering system is controlled manually by underground pump operators starting and stopping pumps according to the level of the dams or reservoirs. The underground hot water reservoirs are used as storage dams for service and fissure water. The mine has to be dewatered constantly to rid the working areas of excess water.

This water is ultimately pumped to the surface, cooled and returned for re-use in the underground mining operations. A typical mine de-watering system is shown in Fig. 1.

To determine the potential for load management on a specific site, information regarding the operation of the de-watering system is retrieved and a typical power consumption baseline is constructed. In this case study, the baseline had already been improved as a result of DSM implementation. This improved baseline shows the power usage throughout the day and, in particular, during the Eskom morning and evening peak periods. A typical, improved, de-watering load baseline for mine A is shown in Fig. 2.

From this baseline it can be seen that...
substantial power consumption still occurs during the Eskom evening peak period. A simulation programme was developed to determine a further amount of power could be shifted to off peak periods while adhering to system constraints. The improved simulated load profile, taking into consideration all the constraints of mine A, is shown in Fig. 3.

The simulation showed a possible shift of approximately a further 5.8 MW out of the evening peak period. Therefore, by implementing a centralised automated control strategy and changing the pump running schedule on the dewatering system a greater energy cost saving could be realised.

Cost effective system automation

Pump instrumentation

When a de-watering system is automated, the system is designed to incorporate safety, ease of operation and sustainability. Standard interlocking and control included in the programmable logic controller, (PLC), is used when the system is operated from a remote location. The pump and motor has a number of critical parameters which must be checked before and during operation. A pump and motor with typical critical pump instrumentation is shown in Fig. 4.

Multiple signals, recorded by appropriate instrumentation, from various points within the process field, are required for correct control. It is therefore cost effective to install multi-core cables and junction boxes. The instrumentation installed on the pump and motor is centralised to a junction box installed close to the pump. This reduces the amount of expensive conventional cable by using multi core copper cables that transmit and receive signals from the junction box to the remote input and output panel. A typical pump junction box installation is shown in Fig. 5.

Using existing installed dam level indication signals, high tension panel cables and instrumentation, the cost of a fully automated system can be significantly reduced.

Communication

All feedback from the underground control system must be reliable. This will ensure that the information from the dam level indicators as well as other critical information is available to the control system in real time. Because the system is controlled from the surface control room the communication network must be stable. Fibre optic cable was used as it proved to be reliable and practical for the installation within the mine shaft [1]. The typical layout of the optic fibre communication backbone is shown in Fig. 3.

Fibre optic cable can transmit large amounts of data on a single fibre pair, depending mainly on the transmitting and receiving equipment capabilities. It is therefore unnecessary to use fibre optic cable with large amounts of fibre pairs for communication. Reducing the fibre core numbers will ultimately reduce cabling costs. If the mine has an existing fibre optic network capable of communicating to the underground pump stations, and there are spare fibre cores available, using the spare fibres for communication will drastically reduce the costs. Thus there is no need for the installation of a new fibre optic mineshaft cable.

Control strategic

The control is done from the surface by making use of a SCADA system. SCADA is the preferred method due to its reliability as well as its ability to communicate with the energy management using the Ole for Process Control, (OPC), protocol [2]. The basic functional diagram of the automated control system is shown in Fig. 6.

A programmable logic controller, (PLC), is installed in each pump station and used for controlling and interlocking on the specified level. PLC communication is accomplished by using the desired protocol to each of the remote input and output panels installed at each pump. The schedule or action to be taken on the specific pump is communicated from the surface control room to the underground PLC, and then to the field instrumentation. Automating the complete dewatering system and controlling it from a centralised station on the surface, made it possible to improve the overall load management. An energy cost saving can be realised by controlling the dewatering pump system running schedule to reduce the energy usage during the Eskom peak period.

Implementing an automated control system

Multiple factors dictate the control on each pump level. Pumps are stopped and started to conform to a specific schedule, resulting in an energy reduction during the Eskom peak period. Certain control
operations that should be avoided with regards to the de-watering pumps are:

- Frequent pump cycling throughout the control [3].
- Utilising more than one pump per de-watering column.
- Operating a pump when its dam capacity is at a minimum level, to avoid the possibility of pumping mud.

It is obviously preferable to use the most efficient pumps more often than the less efficient pumps. The primary objective of the control is to pump as much water as possible to the surface outside of the Eskom peak periods. This will ensure that the underground dams are at a minimum level before peak time. Pumps can now be switched off during the peak times while the underground dams are gravity fed by the inflow of hot water. This will result in a significant reduction in power consumption during the Eskom peak period.

Dam levels are continuously monitored. Pumps will be started if any underground dam reaches its maximum permissible storage capacity, irrespective of the control period. Out of the peak control period, the pumps will normally be started to drain the underground dams, while minimising pump cycling. This procedure is followed on a normal working weekday basis to ensure minimum energy usage during the Eskom morning and evening peak periods.

Results

Implementation of automated control system on the de-watering system produced a substantial energy cost saving due to improved control. The initial power baseline and improved load profile for mine A is shown in Fig. 8.

This figure shows that the implementation of an automated control system on a deep mine de-watering system resulted in a power reduction of 5.6 MW during the Eskom evening peak period. The morning peak also shows an improved power profile. Furthermore, it was shown that precise and sustainable control could be realised using a fully automated system situated in a remote location. The system must have the ability to receive real time information of the complete process.

Due to the de-watering system being in cascade form, the lower levels will affect the inflow of the higher levels. Optimised load control is only possible when all the levels are controlled simultaneously with real time process data.

Conclusion

Investigating the operation of a de-watering system will determine the potential for load management. A simulation model showed that improved load potential is possible with the present system constraints.

The de-watering system was successfully automated and controlled from a centralised point using the energy management system.

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References


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