Reconfiguring mining compressed air networks for cost savings

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ABSTRACT

Title: Reconfiguring mining compressed air networks for cost savings
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The world is currently experiencing major issues in the energy sector. The ever-growing human population, limited energy resources and the effect of greenhouse gas emissions have become major global concerns for the energy sector, including the electricity generation sector. This dilemma caused electricity providers to revise their generation methods and created a major need for consumers to utilise electricity more efficiently. Demand side management (DSM) is one initiative developed for consumers to efficiently utilise electricity.

Due to their high electricity consumption and technical skills, mines are ideal targets for the implementation of DSM strategies. Therefore, the focus of this study was to investigate South African mines for possible implementation of DSM strategies on their compressed air networks. Compressed air networks at South African mines are relatively old and inadequately maintained. This causes inefficient distribution and use of compressed air. The study will therefore focus on reconfiguring mining compressed air networks for cost savings. Cost savings include financial savings on electricity bills, implementation costs and decreased maintenance.

Through several investigations, the possibility of implementing energy savings strategies to reconfigure the compressed air networks of two South African mines was identified. Reconfiguring the networks would respectively entail interconnecting two shafts and relocating a compressor from an abandoned shaft to a fully productive shaft.

Theoretical simulations were developed to determine the networks' responses to the reconfiguration strategies. The simulations assisted in exposing the viability of implementing the reconfiguration strategies on the respective compressed air networks. Positive responses were obtained from the simulations and proposals were made to the respective mines for possible implementation.

The proposed initiatives were implemented on the respective mines' compressed air networks. After implementation of the interconnection strategy, a consecutive three-month performance assessment period commenced to prove the viability of the proposed savings. An average power saving of 1 700 kW was achieved during the performance assessment period. The proposed initiative to relocate the compressor is currently being implemented.

A financial saving of approximately R8.9 million per annum was achieved by implementing the interconnection strategy. The large financial saving was due to the utilisation of the mine's salvaged equipment. Further savings were achieved by the decreased maintenance on the mine's compressors. Due to the successful implementation of the interconnection strategy, it is safe to state that cost savings can be achieved by reconfiguring mining compressed air networks.

Keywords: Energy sector, Electricity generation, Demand side management, South African mines, Compressed air networks, Reconfiguration, Cost savings, Interconnection, Relocation, Simulations, Performance assessment

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LIST OF SYMBOLS

Symbol		Description
#	-	Denotes a mining shaft: 1# refers to number one shaft
%	-	Percentage
&	-	Denotes the word “and”
@	-	Denotes the word “at”
η	-	Efficiency
μ	-	Dynamic viscosity
ρ	-	Density of air
Δp	-	Pressure loss between two points
A	-	Area
C	-	Discharge coefficient
Cp	-	Specific heat capacity of air
D	-	Diameter
e	-	Absolute pipe roughness
f	-	Darcy-Weisbach friction coefficient
g	-	Gravitational acceleration
k	-	Specific heat ratio for air
L	-	Length
$\dot{m}$	-	Mass flow rate
n	-	Polytrophic constant for isentropic compression
P	-	Power
p	-	Pressure
Q	-	Volume flow rate
R	-	Gas constant for air
Re	-	Reynolds number
T	-	Temperature
v	-	Flow velocity
W	-	Mechanical energy
Z	-	Altitude

LIST OF UNITS

Unit		Description
°C	-	Degrees Celsius
CFM	-	Cubic feet per minute
GWh	-	Gigawatt hour
K	-	Kelvin
kg/m.s	-	Kilogram per meter second
kg/m^3	-	Kilogram per cubic meter
kg/s	-	Kilogram per second
kJ/kg	-	Kilojoule per kilogram
kJ/kg.K	-	Kilojoule per kilogram Kelvin
km	-	Kilometre
kPa	-	Kilopascal
kW	-	Kilowatt
kWh	-	Kilowatt hour
m	-	Meter
mm	-	Millimetre
m/s	-	Meter per second
m/s^2	-	Meters per square second
m^2	-	Square meter
m^3/h	-	Cubic meter per hour
m^3/s	-	Cubic meter per second
MW	-	Megawatt
MWh	-	Megawatt hour

LIST OF ABBREVIATIONS

Abbreviation		Description
CO^2	-	Carbon Dioxide
CV	-	Control Valve
DCS	-	Dynamic Compressor Selection
Dr	-	Doctor
DSM	-	Demand Side Management
EE	-	Energy Efficiency
ESCO	-	Energy Savings Company
FPP	-	Flow- and Pressure-Measuring points
GP	-	Gold Plant
IGV	-	Inlet Guide Vanes
INEP	-	Integrated National Electrification Programme
Ltd	-	Limited
M & V	-	Measurement and Verification
MV	-	Manual Valve
NP	-	No-Measuring Point
PA	-	Performance Assessment
PLC	-	Programmable Logic Controller
PP	-	Power-Measuring Point
PT	-	Pressure Transmitter
Pty	-	Proprietary
R	-	South African Rand
REMS	-	Real-Time Energy Management System
SCADA	-	Supervisory Control and Data Acquisitioning
SSM	-	Supply Side Management
VSD	-	Variable Speed Drive

LIST OF TERMS

Term		Description
Agitation	-	Brisk stirring or disturbance of a liquid by using compressed air.
Blasting	-	Explosion of the rock face after insertion of explosives in drilled holes.
Blow-off	-	Air compressor pressure release to increase the flow through the machine, preventing it surging.
Compressor house	-	Building on the mine's premises containing the air compressors used.
Compressor surge	-	A sudden drop in an air compressor's delivery pressure, causing the compressor to oscillate violently.
Demand side management	-	An electricity savings method financed by Eskom and usually implemented by an ESCO to positively influence the various national users' electricity consumption patterns.
Eskom	-	South Africa's main electricity generator and supplier.
Hoisting	-	Extraction of mined ore from underground operations to the shaft's surface.
Load shedding	-	Cutting the electrical current on certain power lines off when the electrical demand tends to exceed the supply capacity.
Loading box	-	Container in which mined ore is added for transportation to the extraction tipping points.

Refuge bay	-	Used by mine personnel as a place of safety during emergencies, for example fires.
Reserve margin	-	Difference between the electricity generation capacity and demand.
Shaft bottom	-	The bottom of a mining shaft.
Skip	-	Container used to carry mined ore from underground operations to the shaft's surface.
Stope	-	An escalation in the form of steps made by the mining of ore from steeply inclined or vertical vanes (usually where the ore containing the valuable minerals is extracted).
Sweeping	-	Cleaning and evacuation of ore from the mining levels' surfaces after the blasting procedure.
Tap-off point	-	Point on a compressed air pipeline where additional equipment (compressed air users) can be added.
Tipping point	-	Location where mined ore from the loading boxes is tipped into chutes leading to the shaft's bottom.
Tramming	-	Transportation of ore to the tipping points via locomotives.
Zama zama	-	Illegal miner.