Development of a dynamic centrifugal compressor selector for large compressed air networks in the mining industry

by

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A dissertation submitted for the partial fulfilment of the requirements for the degree

MASTER OF ENGINEERING

In

MECHANICAL ENGINEERING

North-West University: Potchefstroom Campus

Supervisor: Dr J F van Rensburg

Pretoria

2012

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NOORDWES-UNIVERSITEIT
POTCHEFSTROOM CAMPUS

Abstract

Various commercial software packages are available for simulating compressed air network operations. However, none of these software packages are able to dynamically prioritise compressor selection on large compressed air networks in the mining industry.

In this dissertation, a dynamic compressor selector (DCS) will be developed that will actively and continuously monitor system demand. The software will ensure that the most suitable compressors, based on efficiency and position in the compressed air network, are always in operation. The study will be conducted at a platinum mine. Compressed air flow and pressure requirements will be maintained without compromising mine safety procedures. Significant energy savings will be realised.

DCS will receive shaft pressure profiles from each of the shafts' surface compressed air control valves. These parameters will be used to calculate and predict the compressed air demand. All pipe friction losses and leaks will be taken into account to determine the end-point pressure losses at different flow rates. DCS will then prioritise the compressors of the compressed air network based on the overall system requirement.

This software combines the benefits of supply-side and demand-side management. Potential energy savings with DCS were proven and compressor cycling reduced. A DCS user-friendly interface was created to easily set up any mine's compressed air network.

Keywords: Dynamic compressor selector (DCS), demand-side management (DSM), supply-side management (SSM), platinum mine, compressed air network simulation, real-time energy management system (REMS)

Samevatting

Daar bestaan menige sagtewarepakkette waarmee saamgepersdelug-netwerke gesimuleer kan word. Nie een van hierdie pakkette beskik egter oor die funksionalitiet om kompressors van groot saamgepersdelug-netwerke in die mynboubedryf dinamies te beheer nie.

In hierdie verhandeling sal ’n dinamiese kompressorselektor (DCS) ontwikkel word wat verbruikeraanvraag aktief en deurlopend monitor. Die sagteware verseker dat die beste kombinasie van kompressors, gebaseer op doeltreffendheid en posisie in die saamgepersdelug-netwerk, altyd aangeskakel is. Hierdie studie sal op ’n platinummyn gedoen word en die beheer is van so ’n aard dat die veiligheid van die werkers nie in gedrang sal wees nie. Noemenswaardige kragbesparings sal getoon word.

DCS sal skagdrukprofiele van elke skag se saamgepersdelug-oppervlakklep ontvang. Hierdie parameters sal gebruik word om die aanvraag van lug te bepaal en te voorspel. Alle pypwrywingsverliese en lekke sal in berekening gebring word om die eindpuntdrukverliese by verskillende vloeie te bereken. DCS sal dan die kompressorkombinasies prioritiseer volgens die algehele stelselvereistes.

Hierdie sagteware kombineer aanbod- en vraagkantbestuur. Potentsiële energiebesparings is getoon en die kompressor is minder aan- en afgeskakel. ’n verbruikersvriendelike interaksieplatform vir DCS is geskep waarmee enige myn se saamgepersdelug-netwerk opgestel kan word.

Sleutelwoorde: Dinamiese kompressorselektor (DCS), vraagkantbestuur (DSM), aanbodkantbestuur (SSM), platinummyn, saamgepersdelug-netwerksimulasie, deurlopende energiebestuurstelsel (REMS)

Acknowledgements

First and foremost I would like to thank my wife Irene for supporting me during the development of the dynamic compressor selector (DCS) and the writing up of the results.

Thanks to my parents, Johan and Elize, without whom this dissertation would not have been possible.

I would also like to thank the following people:

- Dr Gerhard Bolt for the constant motivation and pep talks to find solutions for the more difficult facets of the development of the DCS
- Mr Doug Velleman and Prof Leon Liebenberg for all the technical advice
- Dr Johann van Rensburg, my supervisor, for leading me through the final stages of this dissertation

Lastly I would like to thank TEMM International (Pty) Ltd for funding the research and for the opportunity to do my master's degree.

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List of symbols, abbreviations and terms

Symbols and abbreviations

^{o}C	Degrees Celsius
DCS	Dynamic compressor selector
DSM	Demand-side management
ε	Equivalent roughness [µm]
η_c	Compressor efficiency [%]
EES	Engineering Equation Solver
GV	Guide vanes
h	Enthalpy [J/kg-K]
K	Kelvin
Pa	Pascal
$\dot{m}$	Mass flow [kg/s]
µ	Dynamic viscosity [kg/m-s]
n	Ratio of specific heat
OEM	Original equipment manufacturer
P	Pressure [Pa]
PID	Proportional integral derivative
PLC	Programmable logic controller
R	Gas constant of air [J/kg-K]
REMS	Real-time energy management system
ρ	Fluid density [kg/m^3]
SCADA	Supervisory control and data acquisition
SSM	Supply-side management
STP	Standard temperature and pressure

T	Temperature [K]
v	Fluid velocity [m/s]
VSD	Variable speed drive
W	Watt

Terms

Blasting	During the drilling shift of a mine, holes are drilled into the rock face, after which explosives are placed in the holes and detonated.
Blow-off	Compressor pressure relief valve to expel excess air.
Compressor cycling	Excessive on/off compressor operation.
Drop test	A mining term to determine minimum equipment operating pressure.
Peak-clipping	Energy efficiency project that aims to reduce energy consumption during Eskom's domestic peak times.
Node	Shaft, compressor house or place where two or more pipes are joined.

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