
CONCLUSIONS AND RECOMMENDATIONS

This chapter summarises the key findings and provides further recommendations

5 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

It was identified that compressed air systems contribute significantly to worldwide electricity consumption. Compressed air systems at South African mines were identified as a focus area to reduce electricity consumption. Mines are very dependent on adequate compressed air supply due to its flexibility and ease of use.

A brief overview of mine compressed air systems revealed that these systems are very complex. A lack of extensive knowledge and the complexity of the mine compressed air systems resulted in the inefficient operation of the systems. An opportunity was identified to reduce electricity consumption by improving mine compressed air systems.

Existing energy efficiency projects on industrial projects revealed that mine compressed air systems are generally larger and more complex than most industrial systems. Analysis of existing energy saving initiatives implemented on compressed air systems revealed that most projects are done unsystematically.

This is largely due to a misunderstanding of compressed air systems. Typical mistakes identified include the assumption that a project that reduces the demand for compressed air will automatically result in a direct reduction in compressor power consumption. It was proved that some techniques realised insignificant savings because they did not manage a reduction in compressor power consumption.

Analysis of complex mine compressed air systems can be very time consuming. Simplified approximation methods were developed to evaluate possible energy saving initiatives without using complex equations and simulations packages. These approximation methods were derived from theoretical equations and verified with actual system data. These approximation methods are summarised in Table 13. The approximation methods provided results with accuracies of more than 90% for some projects.

Table 13 – Summary of saving approximation methods

Energy saving technique	Saving approximation method
Reduce compressor delivery pressure	<p>An X% reduction in absolute system pressure will result in a 1.6X% to 1.8X% reduction in compressor power consumption.</p> <p>This is only valid if the compressors can reduce output capacity by 1.6X% to 1.8X%.</p>
Reduce system pressure in selected sections of the system	<p>An X% reduction in absolute pressure will result in an $(X \times Y)\%$ reduction in compressor power consumption; where Y is the percentage contribution to the total system demand by the part of the system that will be controlled to the new pressure.</p> <p>This is only valid if:</p> <ol style="list-style-type: none"> 1. Compressors can reduce compressed air delivery by $(X \times Y)\%$ by means of capacity control systems such as inlet guide vane control, compressor shut down; 2. System pressure will remain unchanged; 3. The controlled portion of the system does not have other uncontrolled connections to the system.
Reduce compressed air flow demand	<p>An X% reduction in flow will result in an $(X \times Y)\%$ reduction in compressor power consumption; where Y is the percentage flow contribution to the total system flow through the part of the system where flow will be reduced.</p> <p>This is only valid if:</p> <ol style="list-style-type: none"> 1. Compressors can reduce compressed air delivery by $(X \times Y)\%$ by means of capacity control systems such as inlet guide vane control or compressor shut down; 2. System pressure will remain unchanged; 3. The controlled portion of the system does not have other uncontrolled connections to the system.

The need for an integrated solution to reduce mine compressed air power consumption was identified. The integrated approach was simplified to consist of only three steps. These steps are summarised in Figure 77:

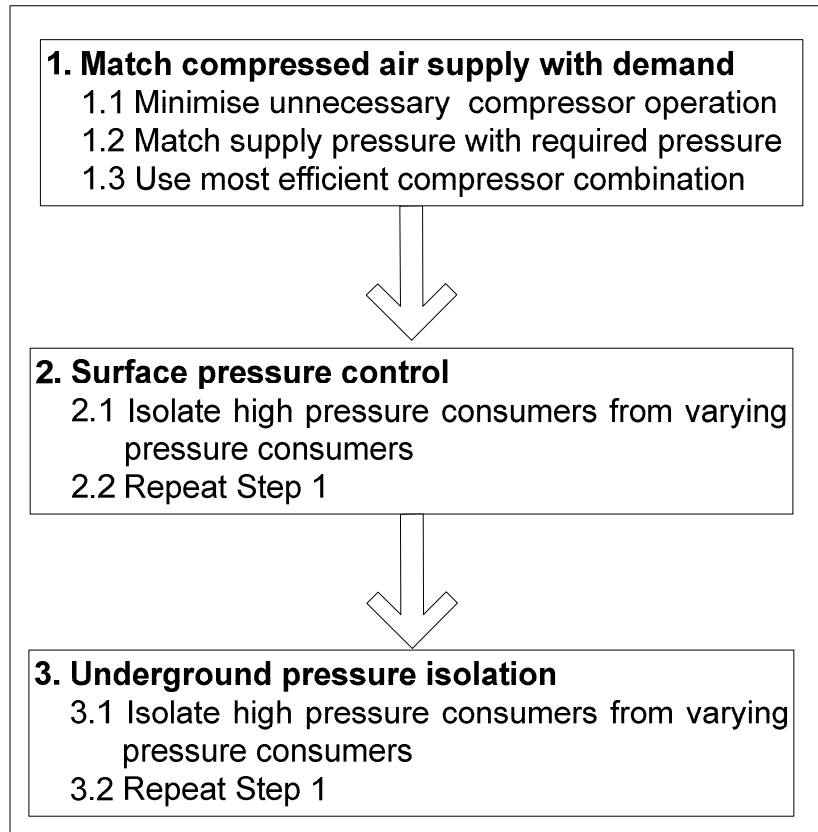


Figure 77 – Flow diagram for integrated approach

The lack of system data and information required a simplified approach to analyse mine compressed air systems and the impact of energy saving projects. Mine compressed air systems were simplified by comparing the entire system to a basic compressed air supply- and demand side system. A simplified compressed air system is shown in Figure 78.

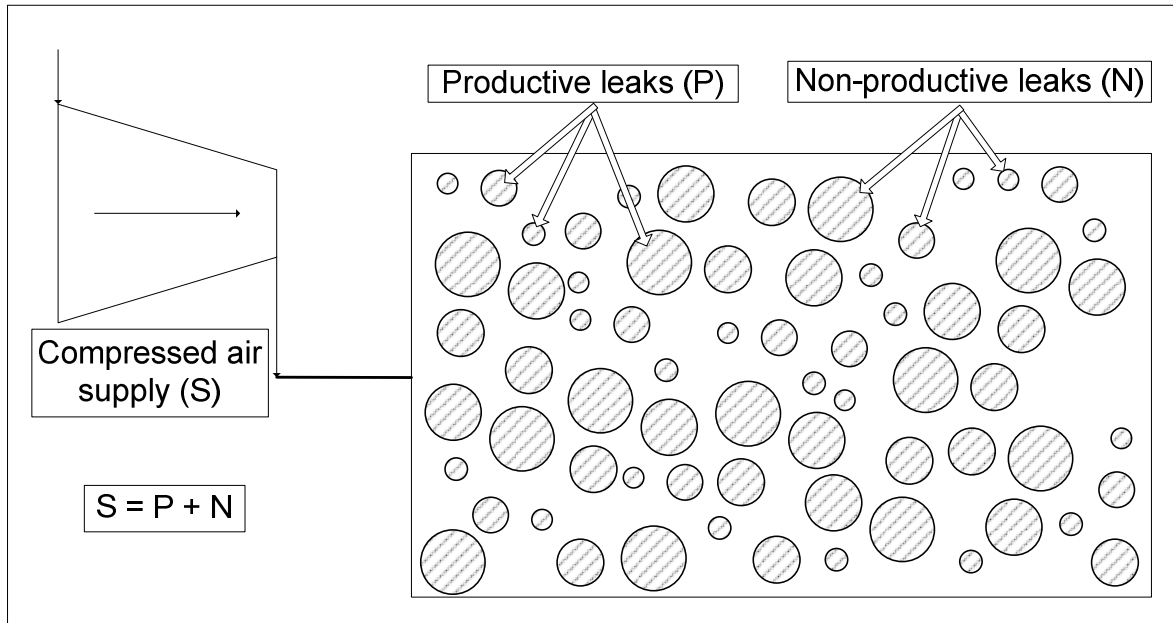


Figure 78 – Simplified view of a compressed air system

The integrated approach was used to reduce compressed power consumption on twenty-two mine compressed air systems. These projects reduced average compressor power consumption by 109 MW. A saving of 109 MW is equivalent to an annual energy reduction of 0.96 TWh. This is equivalent to an electricity cost saving of R315 million per annum (2012 tariffs) [65].

Project costs to the value of R795 million would be recovered within 12 months by using the electricity cost savings together with the Eskom funding model. The implementation of the integrated approach could be applied to other industrial compressed air systems. This could reduce global electricity demand by 267 TWh. That is more than the total amount of electricity consumed in South Africa.

5.2 Limitations of the new approach

The saving approximation methods were derived by using the theoretical relationship between system flow demand and compressor power consumption. The impact of line friction and auto compression was not considered. Values such as pressure drop throughout the system as well as auto compression due to the depth of the shafts were determined through actual measurements where possible. A lack of sufficient information necessitated the use of assumptions in some cases.

It was assumed that the intended energy saving initiatives would not have a notable effect for small changes to these values. The saving approximation methods were verified by comparing estimated figures with actual data from projects implemented on mine compressed air systems. This comparison proved that these approximation methods are suitable for use on mine compressed air systems that operate between 300 kPa and 700 kPa.

The approximation methods were, however, not verified for non-mining applications. It was also not tested beyond the pressure range of between 300 kPa and 700 kPa. The saving approximation methods must therefore be evaluated against non-mining applications and systems that operate at different pressure ranges before such systems are analysed.

5.3 Recommendations for further work

The saving approximation methods did not account for the additional savings achieved due to a reduction in line losses as a result of reduced flow rates. The effect of the lines losses was assumed to be negligible. The derivation of a saving approximation method that includes the effect of line losses would improve the accuracy of the estimation methods.

Efficiency improvements such as enhanced cooling techniques and the replacement of existing motors with higher efficiency motors were not considered. The impact on maintenance routines could also influence compressor power consumption. Dirty inlet air filters could result in significant increases in power consumption. Methods to ensure that maintenance of compressors is done at the correct intervals would reduce losses during the generation of compressed air.

Compressor control improvements realised the most significant savings. Some mine personnel did not allow the full automation of compressed air systems due to a lack of trust in available compressor control systems. It is recommended that more studies must be done to develop reliable compressor control systems.

The implementation of the projects resulted in a reduction in the working hours of some compressors. Only electricity cost savings were analysed to determine the financial impact of the projects. It is likely that the projects resulted in additional benefits such as reduction in maintenance costs. Studies that quantify these maintenance cost savings may prove that some projects initially considered not to be financially viable will become viable if these savings are also considered.

Solutions to remove the demand for compressed air from constant flow applications such as refuge bays and agitation must be investigated. Limited information was found for alternative solutions. Additional research and development of these alternatives could lead to additional savings.