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A REVIEW OF THE CURRENT AND EXPECTED UNDERGROUND COAL MINING METHODS AND PROFILES AND AN EVALUATION OF THE BEST PRACTICES ASSOCIATED WITH THESE

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A dissertation submitted to the Faculty of Engineering and the Built Environment, University of the Witwatersrand, Johannesburg, in fulfilment of the requirements of the degree of Master of Science in Engineering.

Johannesburg, 2010

DECLARATION

I declare that this dissertation is my own unaided work. It is being submitted for the degree of Master of Science in Engineering to the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in any other University.



André William Dougall

23rd day of December 2010

ABSTRACT

Identifying the most effective and efficient production systems and then analysing these to determine the factors contributing to the results is paramount to the understanding, management and planning of future operations. There is a need to increase current productivity levels in underground coal mining and guidelines for achieving this need to be developed. Improvement in productivity and better resource utilisation as a consequence of this research effort, would derive a cost benefit difficult to quantify precisely, but is expected to be of the order of millions of Rand.

Objectives

The objectives of the research were:

1) **To study underground exploitation methods in South African coal mines considering the application and utilisation of certain equipment. This includes identifying recent local (Africa) and international (USA, China and Australia) best practice information as recent top performances have been reported from these countries.**

CM (continuous miner) and ABM (Alpine bolter miner) systems with batch haulage and continuous haulage have been evaluated. ABM single pass machines equipped with CH (continuous haulage) units are not very flexible but deliver from 130ktpm (kilo-tonnes per month) to 160ktpm. The double pass more flexible CM and ABM units have a 3,500t/shift (tonnes per shift) potential. Units have delivered 1Mtpa where conditions allow, however the 2Mtpa target achieved by some Chinese operators is questioned from a cut-out and risk perspective. The better South African sections target 1.4Mtpa to 1.6Mtpa. The industry average is at approximately 60ktpm. Many mines have set their call at 80ktpm per machine.

Wall systems dominate the Australian underground scenario. Production deliveries from a single face of between 5Mtpa and 7Mtpa have been achieved. Highwall entry operations are favoured. Powerful equipment and conveyors appear to be responsible for the difference. The South African wall delivery currently only based at Matla and New Denmark is in the 3Mtpa to 5Mtpa ballpark.

Industry Best Practice is identified and benchmarked results reported.

"Benchmarking is the continuous process of measuring our products, services and practices against our toughest competitor or those companies recognised as industry

leaders. A standard, by which something can be measured or judged" (Scheepers et al, 2000).

2) **To identify pertinent success factors and provide guidelines to management and operators to ensure productivity and effective reserve utilisation.**

A list structured guideline has been developed and is presented. It includes Quality, Costs, Delivery, Safety and Morale (QCDSM), Standard Operating Procedures (SOP's) and the Kobayashi Twenty Keys adapted for mining, to promote deliveries.

Reserve utilisation has been problematic. Partial pillar extraction such as the Nevid system, are currently favoured. Historical methods of pillar extraction are looked at and reported on. Rib pillar extraction has lost favour due to reduced development production.

3) **To identify factors that influences the choice of underground mining methods.**

Economic, technological, and geological criteria have been mentioned and expanded on with geotechnical factors and the provision of methodologies to assist in making the choice.

4) **To identify factors relating to equipment selection.**

The choice between continuous haulage (CH) and batch systems either shuttle car (SC) or battery haulers (BH) have been considered and dealt with. The competitive advantage gained by continuous miners (CMs) and Alpine bolter miners (ABMs) under specific conditions has also been considered.

Following the literature review, a survey in the form of a questionnaire, personal visits and interviews, including electronic correspondence with management and operators of currently operating systems was conducted. The benchmarking operation was performed to identify new and successful practices that lead to effective results in better performance and increased extraction in underground coal mining operations.

5) **To develop a structured guideline to mine design and operation best practice.**

This is dealt with in the consideration of the mine planning and design process, the mine life cycle and the role of the mining engineer in this life cycle. Twenty six (26) focus areas have been identified and discussed in the penultimate Chapter.

The Study

This dissertation deals with a literature review and reports on major research conducted that has influence and impacts this research. Valuable work has previously been performed by Galvin (1981), Beukes (1992) and Lind (2004) amongst others.

The dissertation deals with the geology of appropriate current coalfields in South Africa such as the Highveld, the Witbank and some analysis of the Waterberg field. The Botswana and Zimbabwean fields are not overlooked.

Hydrogeology was dealt with to enhance understanding and the researcher looked specifically at consequences in the high extraction environment. The material generated was from a literature review. Here most of the learning is from work conducted by Annandale (2006) and SRK Hydrology Group's understanding of the science.

Rock engineering which has a major impact on design and performance of the preferred high extraction best practice operations is considered from the perspectives of renowned rock engineers and offers valuable insight for managers and operators. The material generated was not original research during this project but sourced from literature. The focus was on the secondary extraction environment. Most of the learning is from van der Merwe and Madden (2002) and SRK Rock Engineering Group's understanding of the technology.

Choice of underground mining methods and factors that influence choice is not new in the literature. Its application is still very current and purposeful. Owing to its relative importance this has been reinforced. Applied techniques in this field, (as has been used in a case study, by this researcher and found to be effective) have been included. Work by Buchan et al (1981) is still very appropriate and has accordingly been reinforced in this work. No design can be performed without systematically working through the elements which have been grouped into broad economic, technological and geological classes.

A discussion follows, of thick seam and thin seam mining methods or mining profile if they have been identified by managers as having best practice potential. Here innovative technologies that assist in contributing to better performance are also examined.

Work performed by this researcher at Morupule Colliery during a prefeasibility and feasibility stage was considered as a case study and identifies some of the issues design engineers need to consider in the areas of hydrology, rock engineering and method selection.

Chapters looked at certain best practice mining methods including international methods. Here the focus is on technology and layout and to some extent the identification of key performance indicators. One chapter deals with wall methods and the other with pillar methods including partial extraction, pillar extraction and partial pillar extraction.

The research looked at the pertinent factors identified by the benchmarking exercise. What characterises best practice and what gives certain operations 'the edge'. It is in this research document that the application of the soft issues is discussed. There is a trend of

evidence that where the soft issues have been applied the production deliveries have improved. Further data needs to be generated to prove the correlation. This research has identified continuous improvement parameters and key performance indicators such as QCDSM. The guidelines suggest the use of SOPs which have been identified by management as good practice in the coal mining workplace and also suggest the application of the Twenty Keys as adapted for mining. Other systems such as Six Sigma developed by Motorola and applied to mining, have been considered. The better performers have a system they apply. This research offers and has tested such a system. It has applied soft systems thinking.

The Design Guideline deals with the Mine Planning and Design process and also refers to the elements of an effective mine plan, it looks at mineral reporting codes and competency. Appropriate Engineering Council of South Africa outcomes have been identified.

Conclusions and Findings

In Chapter 14 conclusions and findings are drawn in the context of the objectives and aims of this research as was developed for each chapter.

The aims and objectives of the research have been met. A guideline has been generated. The report content has been successfully used to transfer knowledge to the B. Tech. (Mining Engineering) candidates of the University of Johannesburg, Mining Department during 2010 and will continue as course learning material to this target population.