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REPLACEMENT OF EARTHMOVING EQUIPMENT AT SURFACE COAL MINING OPERATIONS IN SOUTH AFRICA

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A research report submitted to the Gordon Institute of Business Science, University of Pretoria, in partial fulfilment of the requirements for the degree of Master of Business Administration.

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ABSTRACT

In order to mine coal, South African surface coal mining operations are heavily dependent on their earthmoving equipment fleets. These equipment fleets represent large capital investments by the companies. Mine management must make complex decisions on their deployment, maintenance, and retirement. They have finite physical and economic life and require replacement at some stage. However, different methodologies are employed to determine the timing of earthmoving equipment replacements. These vary from complex financial models to an intuitive knowledge that a machine must be replaced at a particular time.

This study investigated the replacement of earthmoving equipment at coal mining companies and contract earthmoving companies. It also explored the recommendations of the equipment suppliers. This was done by conducting in-depth interviews with five coal mining companies, four contractor companies and three equipment suppliers.

The results showed that large companies do economic analysis, as recommended by the equipment suppliers. They incorporate the quantifiable factors of increased maintenance cost, decreased performance and technological improvements. Smaller coal mining companies and contractor companies generally only consider historical cost and performance trends and there is scope for improving the replacement decision of their earthmoving equipment.

DECLARATION

I declare that this research project is my own, unaided work. It is submitted in partial fulfilment of the requirements of the degree of Master of Business Administration for the Gordon Institute of Business Science, University of Pretoria. It has not been submitted before for any degree or examination in any other university.

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Colin du Plessis

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LIST OF ABBREVIATIONS

CCM	Cumulative cost model
DCF	Discounted cash flow
EAC	Equivalent annual cost
EME	Earthmoving equipment
ERA	Equipment replacement analysis
ERP	Enterprise resource planning
EUC	Equivalent unit cost
FCP	Failure cost profile
JSE	Johannesburg Stock Exchange
LCC	Life cycle costing
MARC	Maintenance and repair contract
MAPI	Machinery and Allied Products Institute
Mt	Million tonnes
NPV	Net present value
OEM	Original equipment manufacturer
PM	Plant maintenance
ROI	Return on investment
ROM	Run-of-mine
TOC	Total cost of ownership
WACC	Weighted average cost of capital

1. PROBLEM DEFINITION

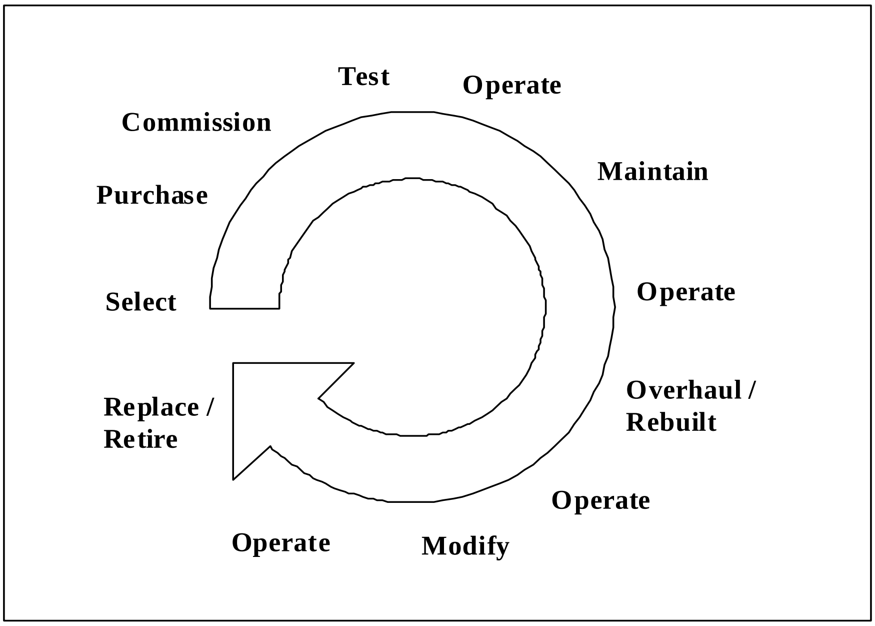
1.1. Introduction

Surface mining methods are extensively employed in South Africa to extract a wide range of mineral deposits located at relatively shallow depths below the earth's surface. These include the mining of coal, diamonds, gold, iron ore, platinum, nickel, phosphate rock, vermiculite, uranium and zinc. This also covers the quarry mining of various raw materials for the construction and building industries, like sand, gravel, limestone, gypsum and dimension stone (Department of Minerals and Energy, 2006).

One of the most critical elements of surface mining operations is the primary earthmoving equipment, such as shovels, loaders, haul trucks, dozers, drill rigs, excavators and scrapers, which are directly employed in the mining process. Ancillary mobile equipment such as graders, tyre dozers, service trucks, cranes, tool carriers and skid loaders are also required to provide other important services. Mine management is tasked with the responsibility of making complex decisions on the purchase, deployment, maintenance and replacement of the mining equipment.

Surface mining equipment has a finite life (Vorster, 2006). The equipment life cycle (Figure 1) starts with the selection, purchase, commissioning and testing, before entering its operating phase. This phase also includes the maintenance and, possibly, the overhauling, rebuilding and modifying of the machine. At various stages in the life of earthmoving equipment, decisions are required on their retirement and replacement.

Figure 1: Simplified Equipment Life Cycle (Tomlingson, 2000)



Eschenbach (2003) identifies five reasons for the replacement of equipment:

- reduced performance of the ageing equipment;
- altered requirements for using the equipment;
- obsolescence due to a new improved model;
- the risk of catastrophic failure or unplanned replacement; and
- shifts between renting, leasing and owning.

Surface earthmoving equipment is classified as a fixed asset and replacements are funded from capital expenditure budgets. Therefore, the Return on Investment (ROI) is maximised when replacement occurs at the optimal economic life of the equipment. The economic life is defined as the age that minimises the average owning and operating costs (Mitchell, 1998). This includes the purchase, operating and maintenance costs, less any salvage values. However, determining this optimal age of equipment can be a complex problem, as it is based on a high number of variables, intricate interaction between the different costs involved, forecasting of costs with a high degree of uncertainty and a large number of assumptions.

There is a trade-off between capital and operating costs. Extending the life of equipment past its economic life will result in higher operating costs, while replacing the equipment too soon destroys shareholder value as the capital could have been used more effectively in another project.

1.2. Research Problem

The objective of the study was to investigate the replacement decision of earthmoving equipment at surface coal mining operations in South Africa.

1.3. Relevance of topic to business in South Africa

The relevance of this topic becomes evident once the following two important aspects are explained:

- firstly, the importance the coal mining industry in the South African economy, including the role of surface mining; and
- secondly, the costs involved in replacing earthmoving equipment on surface coal mines.

A report on South Africa's mineral industry (Department of Minerals and Energy, 2006) places the role of the coal mining industry, and surface coal mining, in the overall economy of South Africa, into perspective. In 2005, South Africa produced 306 million tonnes (Mt) of run-of-mine (ROM) coal, of which 245 Mt was of a saleable quality. Surface coal mines accounted for 53% of the total ROM production in 2005.

Approximately 173.4 Mt of the saleable coal produced was for domestic consumption. The majority of this was consumed in the electricity sector (106 Mt) and the synthetic fuels sector (41 Mt). The remainder of the domestic production was for other smaller consumers like the metallurgical and industrial industries. The remaining 71.4 Mt of the total saleable coal produced was exported and earned R21,4 billion in revenue. Lastly, the South African coal mining industry also directly employs approximately 57,000 people. There can be no doubt about the importance of the coal mining industry in South Africa.

The costs involved in purchasing the replacement surface mining equipment are substantial. According to a pricing guide published by Western Mine Engineering (2006), a 20m^3 wheel loader will cost R23.2 million, a 170t off-highway truck will be R13.5 million and a 570kW track dozer will cost R10.4 million (using an exchange rate of US$/ZAR 7.00 to convert figures into Rand terms).

The equipment fleets of surface coal mines vary considerably in size, and depend on a number of factors, such as the production volumes, mining method and strip ratios. A large-size opencast mine could have a mining equipment fleet of several dozen machines. Optimum Colliery, a BHP Billiton owned mine in Mpumalanga that produces 13.5 million tonnes of saleable coal per annum (BHP Billiton, 2007), operates a mining fleet that consists of more than 50 Caterpillar machines (Kattowitz, 2006). A study by Stewart (2006) estimated that the total replacement value of the surface mining equipment of BHP Billiton is approximately $1.1 billion.

To place the financial impact of surface mining equipment replacement into perspective, a report by Construction Equipment (2007) shows that mining companies on average, replace approximately 10% of their surface equipment annually. It is therefore understandable that South African mining companies spend enormous amounts of capital annually in replacing their surface mining equipment.

1.4. Delimitation and Limitations

This study focuses on the replacement decision of earthmoving equipment. This type of equipment is mainly used in the civil engineering and surface mining industries to move, or to assist in moving, large volumes of soil, rock and ore. The study excludes the replacement of electrical-powered, mega earthmoving equipment like draglines, bucket wheel excavators, dredges and shovels. It focuses on the more mobile, diesel-powered, earthmoving equipment types like wheel loaders, off-highway trucks, track dozers, wheel dozers, graders, excavators and scrapers. These mobile machines are also referred to as heavy construction equipment.

1.5. Research Motivation

Coal is a commodity and the only strategy available to coal mines for gaining a competitive advantage is by producing coal at the lowest cost. The lowest cost producer is the player that should have the highest profit margins and be able to survive commodity price fluctuations best. There is therefore a continual drive to shave off costs from every element of the value chain, whilst at the same time aiming to maximise production.

This study helps to explore the replacement decision of surface mining equipment. It is a complex issue with a high number of variables and uncertainties. Shareholder value is destroyed by replacing earthmoving equipment too soon or too late and coal mining companies will undoubtedly benefit if the timing of equipment replacements is optimised.

2. THEORY AND LITERATURE REVIEW

2.1. Introduction

Before the relevant theory base and literature review is given, it is necessary to explain the nature of the costs associated with earthmoving equipment. There are two main cost categories. The first category is the owning costs, which Vorster (2003, p.63) defines as the cost of "having a machine and keeping it in your fleet". It includes transactions such as the purchase, finance, insurance, taxes and resale of the machine. The owning costs of a machine are usually classified as fixed costs and they accrue regardless of the utilisation of the machine. Another important characteristic of owning costs per hour, is that it decreases as the machine works more hours.

The second cost category is the operating costs, which are the costs required to perform work with a machine. It includes the costs for fuel, maintenance and repairs, tyres and other consumables. Operating costs are variable in nature and vary directly according to the amount of work performed by the machine, which is usually measured in hours worked. In contrast with owning costs, the operating costs per hour of a machine tend to be low when it is still new, before increasing as the machine ages (Vorster 2003).

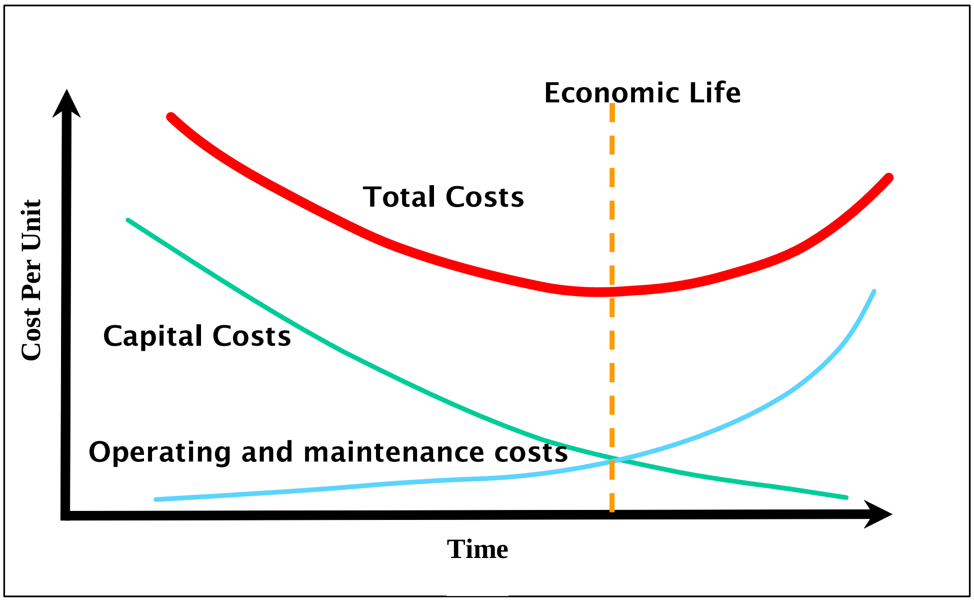
2.2. Classic Equipment Replacement Theories

In the literature review, the classical equipment replacement theories are discussed. The second section focuses on replacement models developed specifically for earthmoving equipment, before exploring the limitations of the theories and models. Finally, the review elaborates on other relevant cost, performance and revenue factors that might influence the replacement decision.

Replacement theory seeks to answer the question: “What is the optimum economic life of this piece of equipment?” (Mitchell, 1998, p.22). Four early equipment replacement theories were proposed to answer this question for industrial equipment in general and not specifically for earthmoving equipment.

Firstly, Taylor’s cost minimisation model (1923) defines the economic life of a piece of equipment as the period of time that minimises the unit cost of production for the machine. His model is graphically represented in Figure 2.

Figure 2: Cost Minimisation Model (Jardine and Tsang, 2006)



The owning costs of a piece of equipment decline with time, while the average operating and maintenance costs of equipment increase non-linearly with time. By combining these two costs, the total cost of ownership for a piece of equipment can be obtained, which tends to have a u-shape. The economic life, and thus the optimal replacement age, is at the point that corresponds to the minimum unit cost value.

Taylor's model, however, focuses on the existing machine only. It assumes that the existing machine is replaced with an identical unit and it does not allow for evaluations where replacement with a different machine occurs. Therefore, the performance improvement due to technological advances is ignored – this is termed machine obsolescence.

An alternative model is proposed by Hotelling (1925) where instead of minimising the costs, an attempt is made to maximise the present value of the equipment's output by using discounted cash flow techniques. In addition to the costs, this model also incorporates the revenues, and the average profit is shown over the age of the piece of equipment. The optimum economic life occurs at the apex of the average profit curve and maximises all future revenues minus the costs associated with the production, plus the expected salvage value of the equipment.

The model, however, does not recognise the existence of machine obsolescence due to technological improvements. Another disadvantage of this model is that the individual revenue generated per unit of equipment is often difficult to insolate and in these instances, this model cannot be applied. Lastly, Jaafari and Mateffy (1990) highlight the fact that revenue estimation per unit for earthmoving equipment is generally very difficult and that the application of Hotelling's model to evaluate equipment replacements is therefore impractical.

Preinrich (1940) developed and refined the earlier work by Taylor and Hotelling. He recognised that replacement problems are not only one machine being replaced by another of the same type. He identifies and categorises five types of replacement decisions. Preinrich also addresses the problem of how to account for technological improvements. However, he does not provide a method for making the replacement decision.

Terborgh (1949) was the first person to define the concepts of the defender (the existing machine) and the challenger (the proposed replacement machine). He developed the Machinery and Allied Products Institute (MAPI) model, which was an extension of the cost minimisation model. He redefines obsolescence and introduces the concept of deterioration - a measurement of the decreased performance of the defender over time compared to the challenger.

He also proposes that the sum of the owning and operating costs be converted into time-adjusted annual equivalents. His model then calculates an after-tax return for two alternatives: the first is to replace the defender machine immediately with the challenger, while the alternative is to retain the defender and to postpone the replacement decision for one year.

Various criticisms have also been identified against the MAPI model. It does not allow for comparison beyond the first year and it is therefore not an optimisation model. Other criticism of the model is that it requires an excessive amount of input information. Jaafari and Mateffy (1990, p. 514) regard the MAPI model as “very academic and sophisticated” and not widely used.

Hasting (1969) provides an alternative replacement model called the repair limit replacement method. This method is only applicable when a machine requires repair. In such a case, the first step is to estimate the required repair costs. If the estimated cost exceeds a certain limit, called the repair limit, then the unit should not repaired but rather replaced. Dynamic programming methods are utilised to determine the repair limits. However, since the machine must require repair, this method has limited application in practice.

2.3. Construction Equipment Replacement Models

Replacement models of construction and mining equipment are largely based on the work done by the authors mentioned in the previous section. The most important replacement models and methods developed for earthmoving equipment will be discussed below.

According to Mitchell (1989), Douglas was the first person to dedicate a book to the management of construction equipment in 1975. In his book, Construction Equipment Policy, he describes three methods of making the replacement decision: intuition, cost minimisation, and profit maximisation.

Intuition or “gut feel” relies on the judgement of the individual making the replacement decision. Douglas (1975) found that this is the most common method for making replacement decisions in the construction industry. However, he questions the use of this method, as it is not based on economic principles. He suggests that the individual making the replacement decision is often biased because of the high initial cost price of a new machine, without taking the long-term benefits of reduced operating costs and increased performance into account. Schexnayder (1980) states that although intuition could provide good insight into the relationships governing the replacement decision, but that it can be easily biased.

Douglas (1975, p.22) states: “decisions about heavy equipment replacement should be based on sound economic principles”. He favours the profit maximisation method above the cost minimisation method and recommends that cost minimisation should only be used when revenue or profits cannot be accurately determined.

The next model, called the geometric gradient-to-infinite-horizon model, was developed by Collier and Jacques (1984). It describes how to perform calculations for different cost categories, while also accounting for the time value of money. The cost categories include acquisition costs, repair costs, maintenance costs, tyre costs, downtime costs, obsolescence costs, taxes and insurance costs. Using their model, these costs are defined in terms of geometric gradients and the model is based on minimising the total cost of existing equipment.

Collier and Jacques (1984) developed equations to find the net present value of all the costs associated with the defender, the first replacement challenger and all future replacement challengers. These net present costs are then added to find the overall net present value and once this value is minimised, it represents the optimal replacement age. This model is regarded as realistic and flexible in application.

Vorster and Sears (1986) regard the cumulative costs due to breakdown and downtime as the most important factor in the replacement decision in the earthmoving industries. In their cumulative cost model (CCM), they define the failure cost profile (FCP), which relates the total hourly cost of all resources in the production team to the number of hours the equipment is unavailable. In their model, the importance of realising the difference between frequency and duration of equipment breakdowns is emphasised. According to Mitchell (1998) the cumulative cost model is the only replacement model that incorporates both classic economic replacement theory and repair limit theory.

The geometric gradient-to-infinite-horizon model developed by Collier and Jacques was further refined by Jaafari and Mateffy (1991). Their model is called the equipment replacement analysis (ERA) model. They include inflation and flexibility in inputs to suit a variety of field applications. A sample problem was used to illustrate their valuation model and they developed a computer program to implement it.

2.4. Age-based equipment replacement

Another equipment replacement strategy concerns age-based replacements, where replacement occurs once a certain predetermined fixed age is reached. An example of this replacement strategy is when a particular dozer reaches 50,000 hours, the dozer should be replaced with a new dozer. The replacement age can be determined by various means but is mostly based on minimisation of the life cycle costing (Scarf and Hashem, 2002).

Although this replacement strategy is straightforward and easy to apply, age-based replacements have a potentially significant pitfall. The problem lies in the replacement rule that is applied. A stable environment is required to apply this rule optimally (Woodman, 1996). Changes in the operating and maintenance environment occur regularly, which impacts on the equipment life cycle. The validity of the adopted rule must therefore be continuously reassessed by analysis of the inputs. This tends to negate the benefit of adopting the rule in the first place and the adopted rule tends to be a suboptimal solution, resulting in loss of shareholder value.

2.5. Applying theory to practice

Despite the numerous different replacement models developed to provide a quantitative basis for the replacement analysis, various authors have stated the difficulties of applying theory to practice.

Preinrich (1940) emerges as the first critic by stating that he is not impressed by the practical merits of the theory of economic life. Vorster (1987, p126) says, “Existing methodologies fail because they ignore too many important practical factors in order to satisfy a perceived need for quantitative precision”. Mitchell (1998) concludes that although extensive research has focussed on bringing theory and practice closer together, the reality is that this has not been achieved and that no one model has gained industry-wide acceptance.

One of the main reasons for the difficulties in applying theory to practice is the challenge of accurately forecasting maintenance and repair costs. Replacement theory is highly data dependent and as maintenance and repair costs represent a considerable amount in the total operating cost of a machine, realistic forecasts of maintenance and repair costs are critical.

2.6. Conclusion

The literature review revealed that the owners of earthmoving equipment could apply a variety of methodologies to determine the replacement timing of their equipment. These methods include replacement done primarily on intuition, age-based replacement and replacement after performing an economic analysis.

It was further highlighted in the literature review that equipment replacement should be based on sound economic principles (Douglas, 1975). This implies that a financial valuation is required where the objective is to maximise profit or minimise costs. However, it was further pointed out by a number of authors that economic analysis is not always that easy to apply in practice. The research study was done against this background.

3. PROPOSITIONS

The following two propositions flow from the literature review and are the statements against which the research was conducted:

Proposition 1

All South African surface coal mines, large contract mining companies working on South African surface coal mines and the equipment manufacturers, employ economic analysis (profit maximisation or costs minimisation) to determine the replacement timing of earthmoving equipment.

Proposition 2

All three stakeholders rely on the following factors to determine the replacement timing:

- costs – lower operating and maintenance costs of the existing machine;
- deterioration – decrease production performance of the existing machine; and
- new technology – increased production performance of new machine.

4. RESEARCH METHODOLOGY

4.1. Research Design

A qualitative methodological approach was employed in this study. According to Leedy and Ormrod (2001), qualitative research deals with the complex nature of phenomena and is a way to discover the problems that exist within the phenomena. The research design was descriptive in nature. The purpose of descriptive research is to describe characteristics of a phenomenon (Zikmund, 2003).

The above methodology was selected for this study for the following reasons:

- the research was aimed at investigating and describing the replacement decision of earthmoving equipment;
- the factors used by the mining companies to determine the replacement timing were unknown; and
- the research involved a small population (less than 30) and sample size.

4.2. Population and Sampling

The population comprised the earthmoving equipment professionals employed at the large South African surface coal mines, at the major earthmoving contracting companies that operate at these surface mines and at the original equipment manufacturer (OEMs) that suppliers the earthmoving equipment to the mines and contractor companies. The professionals included the mine managers, engineering managers, section engineers, site managers, general managers, sales managers and other persons involved in the replacement decision of earthmoving equipment. These individuals are generally knowledgeable in the field of equipment replacements.

The population for this study was defined as 22, namely: 12 surface coal mines, 6 contractor companies and 4 equipment suppliers. When dealing with populations consisting of less than fifty, Henry (1990) recommends a census whereby data should be collected from the entire population. An attempt was therefore made to obtain the information on the replacement methodologies data from all 22.

A letter was sent to the companies requesting permission to interview the earthmoving equipment professionals within the company. An example of one of the letters is given in Appendix 1.

The surface coal mines owned by the five largest coal producing mining companies in South Africa, Anglo Coal, BHP Billiton, Exxaro Resources, Sasol and Xstrata, were targeted. In 2005, they produced approximately 90% of the total saleable coal in South Africa (Department of Minerals and Energy, 2006). The smaller public and privately owned surface coal mines were excluded from the study. A directory of operating mines (Department of

Minerals and Energy, 2007) listed 12 surface mines owned by the five largest coal-producing companies.

The equipment professionals associated with the South African coal mines that were interviewed, are listed in Table 1. In total eight people that are employed in various roles at five different mining companies were interviewed.

Table 1: Equipment professionals of coal mines interviewed

INTERVIEWEE	DESIGNATION	MINE / DIVISION	COMPANY
Dereck White	Field Engineer: Diesel Equipment	Middelburg Mine	BHP Billiton Energy Coal
Neil Atkins	Group Investment Manager	Head office	BHP Billiton Energy Coal
Dirk Muller	Assistant Mine Manager	Kleinkopje Colliery	Anglo Coal
Arthur Smart	Engineering Manager	Landua Colliery	Anglo Coal
Jakop du Plessis	Engineering Manager	Central Services	Anglo Coal
Don Wallace	Engineering Manager	Group Services	Xstrata Coal
Rico van Staaden	Mine Manager	Grootegeluk Mine	Exxaro Resources
Japie Botes	Mine Manager	Head office	Umcebo Mining

In addition to the operating surface coal mines, there are also a number of major contracting companies with substantial earthmoving equipment fleets, which are employed on a continuous basis on the operating coal mines. These include Basil Read, Benicon Earthworks and Mining Services, Concor

Mining (Murray & Roberts), Diesel Power, MCC Opencast Mining Contractors (Imperial Group), Moolman Bros and Scharrighuisen Opencast Mining. Equipment professionals from four of the seven contractor companies were interviewed, as given in

Table 2.

Table 2: Equipment professionals at contractor companies interviewed

INTERVIEWEE	DESIGNATION	DIVISION	COMPANY
Mike Watson	Managing Director / Founder / Owner	Diesel Power Opencast Mining	Diesel Power Opencast Mining
Clint Moorcroft	Operations Director	Scharrighuisen Opencast Mining	Scharrig Mining Limited
Gideon van Heerden	Mining Director	Benicon Earthworks & Mining Services	Scharrig Mining Limited
Nick Claasen	Technical Director	MCC Opencast Mining Contractors	MCC Group - Imperial Holdings

The study also aimed to incorporate the perspectives of the major equipment manufacturers on equipment replacement. Four manufacturers, Caterpillar, Hitachi, Komatsu and Liebherr, dominate the local surface mining equipment scene with a combined market share of 85% (Lewis, 2007). Equipment professionals from three earthmoving equipment suppliers were interviewed, as per Table 3.

Table 3: Equipment professionals at equipment suppliers interviewed

INTERVIEWEE	DESIGNATION	DIVISION	COMPANY
Hugh Donaldson	Sales Manager	Barloworld Equipment	Caterpillar Inc
Alex Caldwell	Regional Sales Manager	Barloworld Equipment	Caterpillar Inc
Kerry Hughes	General Manager: MARC Contracts	Hitachi Construction Machinery	Hitachi Construction Machinery
Colin Oliver	Manager: Life Cycle Management	P&H MinePro Services	P&H MinePro Services

4.3. Unit of Analysis

The unit of analysis of the first part of the study was the earthmoving equipment replacement decision at South African surface coal mines, contractor companies and equipment suppliers.

4.4. Data Collection

In-depth, semi-structured interviews were used for collecting the research data. Leedy & Ormrod (2001, p159) state that the semi-structured interview usually revolves “around a few central questions” and is “more likely to yield information that the researcher hadn’t planned to ask for”.

The central questions that were explored during the interviews cover the replacement methodologies that are employed, factors that influence the replacement decision and methods of cost forecasts. The objective of the interviews was to gain an understanding of the replacement methodologies and practices that are utilised at South African coal mining operations. The full list of questions is given in Appendix 2.

The research study was conducted over a period of approximately four months, from June 2007 through to mid-November 2007. Face-to-face interviews were the preferred method of conducting the interviews. However, two telephonic interviews were also conducted.

4.5. Data Analysis

The objective of data analysis is to "portray consistent patterns in the data so the results may be studied and interpreted in a brief and meaningful way" (Zikmund, 2003, p.473). It includes the activities of summarising, categorising, rearranging, ordering, manipulating and separating out relevant data from the whole data set.

According to Leedy & Ormrod (2001, p.160) there is “no single right way to analyse the data in a qualitative study”. They describe data analysis as a process of boiling down a large body of information into a small set of underlying themes through “inductive reasoning, sorting, categorising” (p160).

4.6. Confidentiality

A number of the companies contacted for the interviews agreed to the interviews on condition that the research report is anonymous. The names of individuals and companies are therefore not revealed in this report.

4.7. Limitations of the research

This research study has a number of limitations. Participants were chosen on the basis of access and only earthmoving equipment professionals from companies who were willing to participate in the study, were included.

5. RESULTS

5.1. Introduction

This objective of this chapter is to present the results of the study. The interviews were conducted with eight professionals from five different mining companies, four professionals from four contracting mining companies and a further four professionals from three equipment suppliers. The interview questions revolved around the propositions as defined in Chapter 3.

5.2. Economic analysis

The primary aim of the study was to determine whether South African surface coal mines, contract mining companies working on South African surface coal mines and the equipment suppliers, employ economic analysis to determine the optimal replacement timing of earthmoving equipment. This was defined as Proposition 1.

For the purposes for this study, economic analysis is defined as a financial valuation that incorporates profits or costs of both the existing machine (the defender) and the proposed new replacement machine (the challenger). Analysing historical maintenance costs, or forecasting of future maintenance costs, of a piece of equipment in isolation, was not viewed as financial analysis. The financial analysis must provide a quantitative valuation to choose between two mutually exclusive options: either to retain the defender or to replace it with the challenger.

A summary of the interviewees' responses to the role of economic analysis, intuition and aged-based replacements, is presented in Table 4.

Table 4: Responses to Proposition 1

Company Type	Company	Economic Analysis	Intuition "Gut feel"	Age-based replacements
Mining Companies	Mining Company A	Yes	No	No
	Mining Company B	Yes	No	No
	Mining Company C	No	Yes	Yes
	Mining Company D	No	Yes	Yes
	Mining Company E	Yes	No	No
Contracting Companies	Contracting Company A	No	Yes	Some-times
	Contracting Company B	No	Yes	No
	Contracting Company C	No	Yes	Yes
	Contracting Company D	No	Yes	Yes
Equipment Suppliers	Equipment Supplier A	Yes	No	No
	Equipment Supplier B	Yes	No	No
	Equipment Supplier C	Yes	No	No

Three of the five mining companies confirmed that economic analysis is carried out to determine the optimal timing of equipment replacements. The equipment professionals of these three companies stated that intuition ("gut feel") does not play a role in determining replacements and that economic analysis provides a better solution to the equipment replacement problem.

The other two coal companies do not use economic analysis and rely to varying degree on intuition, along with other factors to decide when to replacement their earthmoving equipment. The age of the equipment is one of the factors that are used by these two companies.

In contrast to the mining companies, where the majority of the companies apply economic analysis, none of the four contracting mining companies uses this methodology to assist in the replacement decision. All four contracting companies stated that intuition plays a role, while two of the companies stated that intuition plays a critical role. Two of the contracting companies indicated that the age of the equipment is used to determine the replacement timing, while the third company uses the age with certain equipment types only.

All three of the earthmoving equipment suppliers stressed the importance of economic analysis to determine the optimal economic life of equipment. The suppliers recommend that a life cycle costing valuation of each individual piece of equipment be done to assist in the replacement decision.

5.3. Critical factors in making the replacement decisions

The second objective of the study was to determine the factors that the mining companies, contracting companies and equipment suppliers regard as critical factors to be considered during the replacement decision process.

These factors could be also be used as part of the economic analysis or in it could be used in isolation.

The literature review suggested that the three most important factors in the replacement decision are increased maintenance costs and deteriorating performance of the existing machine, and improved technology, which results in an increased productivity of the new machine. The three groups of stakeholders were asked to clarify the importance of each three factors in the replacement decision. Table 5 shows the responses of the companies with respect to the important replacement factors.

Table 5: Responses to Proposition 2

Company Type	Company	Maintenance Costs	Deterioration	Technology
Mining Companies	Mining Company A	Yes	Yes	Yes
	Mining Company B	Yes	Yes	Yes
	Mining Company C	Yes	Yes	No
	Mining Company D	Yes	Yes	No
	Mining Company E	Yes	Yes	No
Contracting Companies	Contracting Company A	Yes	Yes	No
	Contracting Company B	Yes	Yes	No
	Contracting Company C	Yes	Yes	No
	Contracting Company D	Yes	Yes	No

Company Type	Company	Maintenance Costs	Deterioration	Technology
Equipment Manufacturers	Equipment Supplier A	Yes	Yes	No
	Equipment Supplier B	Yes	Yes	No
	Equipment Supplier C	Yes	Yes	No

From the table it is clear that all companies in the three stakeholder groups recognise that both increased maintenance costs and deterioration production performance are important factors. However, the importance of improved productivity of a new machine owing to technological improvements is only viewed as important by two mining companies.

5.4. Conclusion

From the responses of the interviewees, it was evident that there is not a universal methodology in use for the replacement of earthmoving equipment in the South African coal mining industry. Three of the mining companies follow a similar approach in emphasising the importance of economic analysis, while the other two mining companies and the contracting companies follow a less quantifiable approach by using intuition, together with analysis of factors like increase maintenance costs, deteriorating performance and technological improvements. All three equipment suppliers advocate a life cycle costing valuation that is aimed at minimising the maintenance costs of the existing machine.

6. DISCUSSION OF RESULTS

This first section of this chapter highlights relevant characteristics of the three main stakeholders in equipment replacements in the South African coal mining industry. It then evaluates the replacement methodologies of these three stakeholders by interpreting their responses during the interviews held, with respect to economic analysis and factors that are considered in the replacement decision process.

6.1. Characteristics of the stakeholders

It is appropriate to first describe pertinent characteristics of the nature of the business of the three stakeholders, as these characteristics will assist to explain the replacement methodologies and strategies of the three parties. These characteristics were highlighted by the equipment professionals during the interviews.

6.1.1. Coal mining companies

With the exception of one company, all the coal mining companies included in the study are part of large multi-national resource companies listed on global stock exchanges. Three of the companies also have secondary listings locally on the Johannesburg Stock Exchange. These companies own the large coal mines in South Africa that have long operating lives.

Three of the surface coal mines of the large mining companies are Eskom dedicated mines on a "cost plus" basis, whereby Eskom covers all the operating costs of the mines, plus a management fee. Eskom also provides for all the capital-funding requirements, including earthmoving equipment replacements. The above-mentioned factors imply that the South African surface coal mines generally have easier access to capital funds to purchase assets and replace earthmoving equipment, in comparison with contracting companies.

The South Africa surface coal mines also generally perform the primary earthmoving activities in-house. These activities comprise the large volume activities of moving dirt and coal by the earthmoving equipment fleets. Typically, the smaller volume earthmoving activities are outsourced to contract mining companies. This, together with the greater certainty owing to the long mine lives and the easier access to capital, enables the mines to invest in the largest earthmoving equipment available on the market. These earthmoving machines are more expensive than the small and medium sized machines and have longer lives.

Typically, only mining companies invest in this size of earthmoving equipment. The market for this large sized equipment is considerably smaller than the market for the small and medium sized machines. As the demand for these machines is relatively limited, their second-hand resale value is also low. Mining companies therefore tend not to sell retired equipment into the second hand market, but rather "cannibalise" the retired equipment. This means that the equipment's spares are stripped off and used to repair similar equipment that is still in operation on the mine.

It was further highlighted by all five of the mining companies that their new equipment is purchased outright by them through internal capital funding retained earnings and not financed over a term through a financial institution. South African mining companies also enjoy a tax incentive to encourage capital investments. The provisions of the Income Tax Act [No. 28 of 1997] provide for the immediate deduction of capital expenditure by mining companies. The contracting companies do not enjoy the same tax benefit.

The last characteristic of mining companies is the quality of maintenance management of their earthmoving equipment fleets. Three of the mining companies have either implemented or are in the process of implementing SAP, as their Enterprise Resource Planning (ERP) system. The Plant Maintenance (PM) module of SAP provides benefits in terms of maintenance planning and execution to mining companies. The quality of maintenance also influences the replacement methodologies of the mining companies.

6.1.2. Contracting companies

Although three of the four contracting earthmoving companies included in the study are listed on the JSE stock exchange, they are much smaller than the mining companies. These contracting companies typically perform the smaller volume mining activities like topsoil and parting removal, which require smaller earthmoving equipment.

Earthmoving mining contracts are generally awarded to the contractors for a relatively short period of two to three years. After the contact expires, mining companies usually request a number of different contractors to tender for the new contract. This results in more uncertainty for the contracting companies and they therefore tend to operate with smaller size earthmoving equipment, as this size equipment is less costly.

In comparison to the demand for the second-hand large earthmoving equipment, the demand for second-hand small and medium sized machines is much greater. This is a result of the larger quantity of equipment as, in addition to the mining industry, the construction industries also utilise these machines extensively. They therefore retain their value better once they become second-hand and there is a larger market to buy and sell second-hand small and medium sized earthmoving equipment. This characteristic influences the replacement strategies of mining and contract companies.

Another important distinguishing aspect of the contracting industry is the way the new replacement equipment is financed. Contracting companies are more capital constrained than the mining companies. All four contracting companies confirmed that new earthmoving equipment is financed by a financial institution, generally over a 36-month period.

The last important characteristic of contracting companies concerns the way that they are managed. The original founders of two of the contracting companies are still actively involved in running the businesses as managing directors. It was stated by the companies that they believe they are less bureaucratic and more entrepreneurial. Decisions to replace earthmoving equipment are therefore made more quickly by the contractors.

6.1.3. Equipment suppliers

The equipment manufacturers and suppliers do not operate earthmoving equipment, although some of the suppliers have equipment rental divisions. Their main function is to manufacture and imported the earthmoving equipment and spare parts needed in the South African surface mining industry. More than 95% of the South African surface mining equipment is imported (Lewis, 2007).

In addition, the equipment suppliers also fulfil an advisory role to the owners of earthmoving equipment concerning the life cycle management of the equipment. However, three equipment professionals interviewed questioned whether replacement advice from the equipment suppliers is completely unbiased.

They believed that the suppliers have a financial incentive to recommend equipment replacement prematurely, as this will improve their new equipment sales. When this perception was posed to the suppliers, the suppliers responded that the opposite is true. The profit contributions from the sales of spare parts of equipment greatly exceed the contributions from the new equipment sales.

6.2. Economic analysis

Three of the five coal mining companies stated that economic analysis is done to determine the optimal timing of equipment replacements. The other two mining companies and the four contracting mining companies do not perform economic analysis to assist in the replacement decision. The three earthmoving equipment suppliers recommend a life cycle costing valuation.

Replacement analysis comprises a choice between mutually exclusive alternatives where one of four decisions can be made:

- null decision / status quo - operate as before (keep defender);
- overhaul to maintain or improve performance of the defender;
- replace existing asset with a new one (get challenger); or
- retire and dispose - no use for it in future.

The next section explores economic analysis in more detail.

6.2.1. Cost minimisation models

Two of the three mining companies that do economic analysis to determine the timing of equipment replacement have a written standard procedure that describes the process to be followed in detail. All three companies use cost minimisation models. It was also apparent that their models are similar in nature and based on the standard discounted cash flow (DCF) model. These models calculate the net present value (NPV) of owning, operating and disposing of a single piece of equipment (the defender) and then compare it with the NPV of purchasing, owning, operating and disposing of a new equipment unit (the challenger).

To account for different lives of the challenger and defenders, two of the three mining companies use an equivalent annual cost (EAC) model. This involves calculating an annuity, which is called the EAC of the NPV over the life of the each of the different life durations. An annuity is an equal payment made once a year over a set number of years to give the specified value with a given discount rate. The discount rate used reflects the two companies' weighted average cost of capital (WACC).

Two different scenarios for replacement can be expected. The first scenario is when the challenger is identical to the defender with respect to its

productivity. This is often termed like-for-like replacements. With these types of replacements the EAC of the defender and challenger are compared.
If the EAC of the defender is less than that of the challenger, the decision should be to keep the defender. Conversely, if the EAC of the defender is more than the EAC of the challenger, the decision should be to acquire the challenger immediately. Any alternative equipment replacement decision would result in a higher cost and a loss of value to the operation.

The second scenario occurs if the challenger and defender have different productivities. This occurs frequently in the mining industry where improvements in technology have allowed for bigger, more productive earthmoving equipment. Mining and contracting companies, seeking the benefits of economies of scale, often replace old ageing equipment with the new larger equipment.

To compare equipment with different productivities, the two mining companies use an Equivalent Unit Cost (EUC) model. The EUC model is similar to EAC model, except that the cost is related to units of production (e.g. R/tonne or R/m^3 moved) rather than time (R/hr operated). Although this model introduces a slightly greater degree of complexity, the principles remain the same and the same replacement decision rules are applied.

The EAC methodology at the two mining companies is regarded as best practice for economic replacement decisions. The two companies that utilise this methodology are part of large multi-national resource companies that dedicate large resources in practices like benchmarking and continuous improvement. The third mining company, which uses economic analysis for replacement decisions, is slightly behind the two leading companies in terms of the quality of their equipment replacement methodology.

6.2.2. Difficulties in economic analysis

A number of difficulties were also identified by the interviewees regarding the application of cost minimisation models to determine the replacement timing.

As with any DCF analysis, the usefulness of results is highly dependent on the quality of the inputs. Forecasting the equipment's operating costs of labour, diesel, tyres and other consumables, is relatively simple. The difficulty lies in forecasting the maintenance costs, especially towards the end of the economic life of the equipment, as the maintenance cost usually escalates dramatically during this period (Vorster 2003).

The three equipment suppliers recommend, and four of the mining companies follow, a life cycle costing methodology to forecast future maintenance costs of earthmoving equipment. This methodology focuses on the sub-assemblies and smaller components within a piece of equipment. The life of each sub-assembly and component is tracked and recorded when replaced. With time, a database of component lives is created. As the costs of the components are known, along with the frequency of replacements, the future maintenance costs can be forecast in this way.

This maintenance cost forecasting methodology has a major drawback in that it is resource intensive. It requires additional maintenance planning personnel, maintenance planning software and a mature overall maintenance management approach by the owner of the earthmoving equipment. Using industry averages for the component lives is not recommended, as the component lives are dependent on site-specific factors such as quality of maintenance, operating conditions and quality of operators. It is suspected that the cost of an accurate life cycle costing system is an obstacle for smaller mining companies against introducing economic replacement analysis for earthmoving equipment.

In addition to the maintenance costs, the residual value of the equipment is also used in the financial analysis. The residual value is the value of the equipment if sold. As there is a limited market for large second-hand earthmoving equipment, the residual value of equipment is difficult to quantify and a “thumb-suck” value is often used.

Another difficulty that one of the mining companies highlighted is the justification of like-for-like replacements using economic analysis. Because the production capacities of the defender and the challenger are identical, the replacement is largely based on a saving in maintenance costs that the new machine will yield.

In practice, the financial model usually suggests the replace decision only when the equipment is close to the end of its physical life and when a large investment is required to keep the machine in operation. Equipment professionals at two companies admitted that they know of instances where the inputs in the models were manipulated to achieve a predetermined result.

6.3. Equipment replacement factors

The next section explains the factors that influences the replacement of earthmoving equipment in more detail.

All owners of earthmoving equipment recognise that increased maintenance costs and deterioration production performance of the existing machine are important factors in determining the replacement timing. The importance of improved productivity of a new machine, owing to technological improvements, is only viewed as important by two mining companies. The other three mining companies and contracting companies generally do not evaluate the productivity gains of new equipment models.

Age was mentioned as an important factor by three contracting companies and one mining companies when replacement decisions are made. These companies often follow a strategy of selling their earthmoving equipment prior to the first major overhaul when large sub-assembly components are replaced. This strategy requires a good market for second-hand earthmoving equipment. To optimise the resale value, the companies stated that they prefer to purchase the leading equipment brand names that have a higher demand in the second-hand market.

Although other companies do not make replacement decisions purely on age, they do recognise the importance of managing the average age of their equipment fleets. They are conscious that the age of equipment must be balanced, as this will reduce the risk of operating with an old, unreliable equipment fleet. A balance age distribution of the equipment will also result in a steady replacement capital budget from year to year.

All the companies interviewed also mentioned the importance of the equipment's application in making the replacement decision. If a machine is utilised in the bottleneck process on the operation, it will receive preferential treatment when replacement decisions are taken. Companies do not want to risk prolonging the replacement of these machines, as any production delays due to deterioration of these machines, will result in lost revenue for the company.

7. CONCLUSIONS

In this chapter, the importance of optimal earthmoving equipment replacements and the main findings of the study are summarised. A number of recommendations are then proposed that is aimed at improving the replacement decision-making process of the equipment. The chapter concludes with suggestions for further research.

7.1. Main findings

An important aspect of sustaining production at large surface coal mining operations is the replacement of their earthmoving equipment. Some equipment managers are of the opinion that, as long as the equipment is repairable, it should be repaired, regardless of the costs involved. These individuals are often biased by the high capital cost of a new machine, and they do not take the long-term benefits of reduced operating costs and increased performance into account.

Surface mining equipment has a finite economic life that occurs prior to the end of the equipment's physical life. At the end of its economic life, the unit cost of production for the machine is minimised and this is the point at which replacement with a new unit should occur. It was highlighted that there is a trade-off between capital and operating costs. When the life of equipment is extended past its economic life, it will result in higher operating costs. Conversely, if the equipment is replaced too soon, shareholder value is destroyed, as the capital could have been used more effectively on other projects.

Poor replacement decisions can significantly affect the equipment's performance and its operating costs. This in turn could determine whether the operation's production outputs and budgeted costs are achieved. Earthmoving equipment professionals of the mining and contracting companies therefore need to identify which equipment should be replaced, what new equipment type should be purchased and when to replace the identified equipment.

The literature review showed that equipment replacements should be based on sound financial principles. Three of five coal mining companies use economic analysis that are aimed to minimise costs when evaluating replacement options. These three mining companies form part of large multinational companies with well-established procedures for asset and maintenance management.

These companies also mentioned a number of difficulties encountered in the economic modelling. These included forecasting maintenance costs and determining residual values. In practice, it is difficult to justify like-for-like replacements using the cost minimisation model. Equipment professionals at two companies admitted that they know of instances where the inputs in the models were manipulated to achieve a predetermined result. If assumptions, that are more aggressive, are used in the model, it is possible to change an answer from keeping the defender, to purchasing the challenger. This is a corporate governance concern that should be addressed by the companies.

The other two mining companies and the four contracting companies follow a more informal and less quantifiable approach to earthmoving equipment replacements. Generally, a review of historical cost and production performance trends are carried out. In addition, other factors such as technological improvements of the new equipment, the rand dollar exchange rate and resale values of second-hand equipment will also be reviewed.

These companies believe that experienced equipment professionals can make a replacement decision based on intuition after reviewing the factors that influence the replacement decision. Even though experience is an important attribute of equipment managers, and their intuition could be accurate at times, this is not a scientific method that can be consistently applied with a high degree of confidence.

Age-based replacement of earthmoving equipment is also a sub-optimal solution to the replacement problem. A stable environment is required to successfully apply a replacement rule. However, the operating conditions and the maintenance environment are generally not constant. These changes can affect the equipment's life cycle and cause the adopted rule to become sub-optimal.

It is therefore concluded that the optimal replacement decision-making process is not employed at two of the mining companies and at the four contracting companies.

Adopting and implementing an effective equipment replacement strategy, will result in an improvement in the bottom-line figures of both mining and contracting companies. Although the optimal replacement of earthmoving is generally not applied at the South African coal mining operations, it is firmly believe that the knowledge to do so, is in the industry and that a transfer of knowledge should occur.

7.2. Recommendations

A number of recommendations are proposed that could potentially improve the decision-making process for the replacement of earthmoving equipment at both mining and contracting companies.

One of the most important recommendations is for all mining and contracting companies to draft and introduce a formal policy for the replacement of their earthmoving equipment. The policy should advocate that the replacement decision should be based upon on costs and performance considerations and that detailed economic analysis is critical in the decision making process.

The equivalent annual cost (EAC) model is the most suitable model for the replacement of earthmoving equipment and is the recommended methodology. Appropriate discount rates, that reflect the companies' WACC, should be used in the evaluation. The replacement policy should further be communicated and entrenched as standard practice in the companies.

It is also important to educate and train the relevant operational, engineering and finance staff to understand the complex nature of equipment replacements in the mining industry. This should include the theory of equipment replacements, life cycle costing, discount cash flow analysis and equivalent annual cost models. It should also explain the impact of factors such as deterioration, obsolescence and technological improvements. Working examples of equipment replacements and financial model templates could also be incorporated in training programmes.

Forecasting of maintenance costs should be based on life cycle costing principles and through detailed analysis of real maintenance data. The methods and systems for capture, reporting and analysis of sub-assembly and component performance data are important. It does not require a sophisticated maintenance planning system such as SAP's Plant

Maintenance (PM) module. A relatively simple database will be sufficient to capture the required maintenance data and to build a statistical database on sub-assembly and other components.

Caution is also required to prevent manipulation of input data, mostly maintenance costs, in the financial models, to achieve a predetermined result. This is a corporate governance concern as capital funds are used to purchase new equipment. To prevent this from occurring, there should be a clear audit trail of key assumptions used in the financial models and these should be documented in the capital motivation that the board of directors approves. Internal reviews and audits of the capital motivation could also play a role in preventing unnecessary capital expenditures.

It is also recommended to follow the replacement strategy once it has been implemented. There is often a temptation to postpone the purchase of new earthmoving equipment after capital budget cuts are imposed. This is a dangerous tactic, as all earthmoving equipment experiences deterioration and obsolescence. Systematic and continuous replacement is required to ensure that the fleet retains its production capacity.

Earthmoving equipment must be available and reliable to achieve the operation’s production targets. It is important to manage the average age of the equipment fleet carefully. If not, increasing cost and decreasing reliability will significantly influence a company's productivity and profitability and could threaten the survival of company.

It is hoped that this study is one of the first steps in the process of improving earthmoving equipment replacements on South African coal mining operations. The research report aimed to describe the current replacement methodologies that are in use at these operations. An attempt was made to link the current replacement methodologies to the literature review and to highlight both good practices and areas for improvement.

7.3. Suggestions for future research

It is suggested to do a benchmarking study to determine average "optimal replacement ages" for some of the popular earthmoving equipment models, based on average operating conditions, utilisations and maintenance practices. Some of the popular equipment models used on the South African coal mining operations includes the CAT 777 off-highway truck, the CAT 992 wheel loader, the Hitachi EX1200 excavator and the Komatsu D375 dozer.

Data on the selected equipment's prices, life cycles costs and other relevant inputs required for the financial models can be obtained from the equipment suppliers. A comparison can then be made between the average optimal replacement ages and the actual equipment ages in operation on coal mines. This comparison should give an indication to the question if South Africa coal mining companies replace, on average, their surface mining equipment on time, too late or too early.

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9. APPENDICES

9.1. Appendix 1 - An example of cover letter

Mr B Magara

The Chief Executive Officer

Anglo Coal South Africa

PO Box 61587

MARSHALLTOWN

2107

03 July 2007

Dear Mr Magara

Permission to interview Anglo Coal engineering managers

I am a mining engineer at Xstrata Coal who is currently completing a MBA degree at the Gordon Institute of Business Science - University of Pretoria. As part of the requirements of the MBA, I need to complete and submit an Integrative Research Project at the end of this year. My selected topic for this research project is “the replacement of earthmoving equipment at surface coal mines in South Africa”.

I became interested in this topic through my role as Investment Manager of a opencast mine, where one of my primary responsibilities was to assist in investment decisions through financial analysis, risk assessments and value enhancing practices. In this role, I realised that the optimal replacement timing of mining equipment can be a complex issue with high amount of uncertainty and variables.

My aim with this project is to investigate what methodologies are employed at South Africa surface coal mines for the replacement of earthmoving equipment. I would also like to explore what factors are considered most important when the replacement decision is made and what difficulties are confronted by mine management in the replacement process.

With your permission, I would like to interview the Anglo Coal opencast engineering managers or diesel section engineers to gather the required information on the Anglo Coal mines' replacement methodologies. The research report will be anonymous and the names of individual mines or mining companies will not be linked to practices or methodologies. The objective of the study is to describe what the practices and general trends are in the South African coal mining industry with respect to earthmoving replacements. I would also like to stress that this research is undertaken in my private capacity as a part-time MBA student. If required, I can provide Anglo Coal with a copy of the research report once completed.

I would greatly appreciate it if you could consider my request to interview the selected engineers. Should you grant the permission, I would contact the particular people to arrange the interviews at a time convenient to them.

Yours sincerely

Colin du Plessis

9.2. Appendix 2 - Interview questions

Questions to be asked during the interviews:

1. Does your company have an official policy or operating procedure that describes the process to be followed before replacement earthmoving equipment can be purchase?
2. Are economic analysis done to help identify the timing of optimal equipment replacement? (Probe - what method of analysis? NPV, EAC, payback, MAPI, etc.)
3. What role does experience ("gut feel") play when the replacement decision is made.
4. Do the mining process where the earthmoving machine is utilised play role in the replacement decision? Is the "bottle neck process" identified and given preference during the replacement decision?
5. Is increased cost of maintenance of the existing machines considered the most critical factor in the replacement decision? Are maintenance and operating cost recorded for individual earthmoving machines?
6. What methods of maintenance & operating cost estimation are used in replacement decisions (if economic analysis is done)? (Database of historical costs, estimates from OEMs, etc)
7. What rate of inflation is used in the economic analysis? Are different inflation rates used for the different cost components of spares, labour, fuel and consumables?

8. What discount rate is used in the economic analysis? Does the discount rate reflect the company's weighted average cost of capital (WACC)?
9. Is the net resale price or salvage value considered in the replacement decision? How is the salvage values determined?
10. What role does obsolescence play in the replacement decision?
11. Are other earthmoving equipment models from other manufacturers than the existing fleet also considered when the replacement decisions are made? (Brand loyalty - strategic alliances or partnerships with OEMs.)
12. What other factors are taken into consideration when the replacement decisions are made?