Activity Based Costing: Challenging the way we cost underground coal mining systems

by G.H. Lind*

Synopsis

This paper discusses the traditional costing approach currently used in the underground coal mining industry. Activity Based Costing (ABC) is identified as being a potentially more effective manner in which to cost underground coal mining systems. With the use of a costing framework developed by the author incorporating new thinking to eliminate the shortcomings identified in the traditional costing approach, a comparison of two types of underground coal mining systems, viz. continuous miner and longwall, is conducted. It is found that under certain criteria, in all cases, irrespective of the way in which the systems are costed, the continuous miner system is currently the better investment. It is also observed that when a system is costed using ABC that better investment decisions result when compared to costing the same system using traditional costing techniques. It is further seen that traditional costing techniques tend to overestimate the total costs of a mining system. This paper shows one application of ABC that can be incorporated as a management tool.

Introduction

All management requires the allocation of scarce resources in the most appropriate way. This requires prioritization of objectives and it also requires cost benefit analyses so that a decision can be made. As decisions require that estimations be made, there are few exact applicable solutions. Decisions are made on the basis of the information available at that time. The South African coal mining industry relies on capital intensive systems to increase productivity so as to compete on the international market. The underground coal mining industry is capital intensive as a result of it being highly automated. The capital expenditure related to this can often dictate whether a project will be financially viable or not and making the decision to implement a particular mining system may prove to be less than optimal at that particular point in time (as a result of economics), but equally said, the decision that is being made requires acting without perfect knowledge of the outcome. One such approach to make the best possible decision at a particular point in time of a particular underground mining system (as in this case) is to conduct cost benefit analyses of the various underground coal mining methods to aid mine managers (or other decision makers) to make best practice decisions.

There are generally two ways in which systems are costed, viz. the way they are currently costed and the way they could be costed. Costs are important as they impact on the budget of any organization. It thus becomes important to review the way in which these mining systems are costed, as an incorrect (or flawed) costing approach may impact adversely on the budget, or even encourage an incorrect decision to be made on a marginal project and ultimately leading to losses in the long run. The question thus arises whether the underground coal mining industry is using the best costing tools available at its disposal for decision making? The author proposes that the current manner in which underground coal mining systems are costed have flaws and that tools exist to make these approaches more objective. To this end the author discusses the traditional costing approach and introduces a costing framework incorporating elements of different modern costing techniques with a case study. It is important to mention that there is no one best technique and that the framework developed uses the best results obtained by aggregating results from different planning methods.

The traditional costing approach

Costs, irrespective of the method used to obtain them, in any organization form the basis of the profit equation (Equation [1]), whereby the expenses are the costs:

$$Profit = Revenue - Expenditure \quad [1]$$

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 Paper received Jan. 2000; revised paper received Oct. 2000.

It stands to reason that the lower your expenditure, the higher your potential profits. The cost (or expenditure) function is difficult to identify in the classic sense, in that it distinguishes between long run and short run. The short run considers a period in which some factors are fixed and the long run is the period over which factors become variable. Expenditure, or the cost function, can be described by the following equation (Equation [2]):

$$Total\ \cos t\ =\ Total\ Fixed\ Cost\ +\ Total\ Variable\ Cost \quad [2]$$

This Equation represents the short run costs. The fixed cost function would include salaries of staff, general wear and tear of machinery, etc., while variable costs would include raw materials, cost of labour, running expenses of fixed capital, maintenance and repairs, etc. The variable cost function is essentially the operating expense of a project.

What is traditional costing?

Traditional costing systems fundamentally attempt to assign overhead costs directly to products (with the understanding that products cause costs) rather than activities first, and then these activities to product units (to indicate what is spent rather than why it is spent). Traditional systems take the total costs required to produce a number of products and divide these among the various products. All costs incurred thus have to be allocated to one or other product, which can often result in the cross-subsidization of costs. Attempting to identify the exact cost of installing a roofbolt, for example, would be virtually impossible as a consequence of this cross-subsidization as only a generalized cost will be obtained.

Traditional costing systems utilize a single, volume-based cost driver. This is the major reason why the traditional product costing system distorts the costs of products (as will be seen later, it tends to overestimate these costs). Hilton[1] suggests that these types of costing systems assign overhead costs to products on the basis of their relative usage to direct labour. The use of labour as the volume-based cost driver in assigning overheads is, however, becoming an obsolete measure (Glad and Bekker[2]), which often causes inaccuracies in product line costing. A consequence of this is that when overhead costs are cut, it generally leads to a reduction in the quality of the product rather than the long-term cost reduction of the product. This costing technique does not work well for multiple products. When one thinks of a multi-product mine producing coal for export and local consumption, it is difficult to separate the mining activity as, for example, a blending operation to obtain the right product may skew the costing analysis. Further, this costing approach does not identify variable/avoidable costs (as these are absorbed into other costs rather than reported on separately) and often focuses the manager's attention on the process to achieve the final product rather than the final product itself. A further and perhaps more important shortcoming of the traditional costing approach is that the cost of technology (capital) is often treated as a period cost not taking into account the extent of its use. In the capital intensive underground coal mining industry, this consideration is of great importance and must be accounted for in the cost benefit analyses.

When considering the underground coal mining industry, use of the traditional costing approach is made in the form of Process Costing (PC). The coal mining industry uses 'ton of coal mined' as its unit of measure rather than labour. PC is commonly used as the costing measure in systems where the outputs are continuous (as opposed to batch outputs) and is designed for the accumulation of costs for mass production like units (one ton of coal in our case). It makes no attempt to account for the costs of individual units or specific groups of products. Instead, operations or processes accumulate costs which are subsequently allocated from processes to products on a systematic basis.

The major shortcomings of the traditional costing approach (which includes Process Costing) can thus be summarized by the following points:

- ➤ Cross-subsidization of costs
- ➤ Cost of technology (capital) is treated as a period cost
- ➤ Processes rather than specific groups of products are costed
- ➤ Difficult to account for multiple products.

The way coal mining systems are currently costed

Falconer[3] documented a costing approach, which formed the basis for his analysis of costing three underground coal mining methods. In terms of the definition of the costing systems above, the way Falconer conducted his research was based on the traditional costing (Process Costing) technique. He conducted his analysis on an equivalent basis (to provide a Rand per ton of coal mined value) in an attempt to identify the most cost effective mining method from conventional drill and blast, mechanized continuous mining, and mechanized longwalling. His analyses were based on the following assumptions:

- ➤ Seam height = 3 m
- ➤ Competent sandstone floor
- ➤ Coal roof
- ➤ Depth below surface = 90 m
- ➤ For continuous miner methods, bord widths = 6 m, and pillar centres = 18 m.

He further specified that a producing colliery with existing infrastructure was required to increase output by 150,000 tons per month by the installation of new mining equipment. His results are summarized in Table I.

This analysis showed that the conventional drill and blast mining system was the least expensive (from an operating point of view) while longwall was the most expensive. It should be noted that when Falconer conducted his analysis the longwall mining method was still trying to establish its mature learning curve in South Africa in terms of productivity. Since this analysis, conventional drill and blast operations have largely been replaced by mechanized mining systems. Lind[4] commented that Falconer's analysis gives no indication as to whether the systems are a good investment or not.

Table I

Summary of Falconer's[3] results

Mining System	Cost (Rand/ton)
Drill and Blast	18,24
Continuous Mining	19,32
Longwall	25,02

The way in which Falconer costed the three mining systems forms the *status quo* of the way in which South African coal mines in general cost their operating expenditure (i.e. Process Costing). If one was to use the costs obtained with the PC technique to input into financial analyses, a potential bias could exist as a result of the way these costs were obtained (as shown above), and the resulting decision may be flawed. As decisions are made on the basis of the information available at that specific point in time, this traditional manner of PC would give a specific and potentially skewed output on which to base a decision. Since the entire coal mining industry costs their operations using PC, a costing alternative (in the form of Activity Based Costing) is suggested, which could be of benefit to the underground coal mining industry as a whole.

A costing alternative

It was mentioned earlier in this paper that no one best cost benefit analysis exists, but rather that the best results are obtained by aggregating results from different planning methods. With this in mind the author identified that Activity Based Costing[2,5,6] (ABC) is a more appropriate means of obtaining operating costs than the traditional costing techniques. An overly simplified schematic explanation (including a basic example) of the ABC process is depicted in Figure 1.

ABC differs primarily from traditional costing techniques through the way it treats non-volume related overhead costs. By non-volume related is meant the previously ignored indirect costs, e.g. the mine's security function on the overall

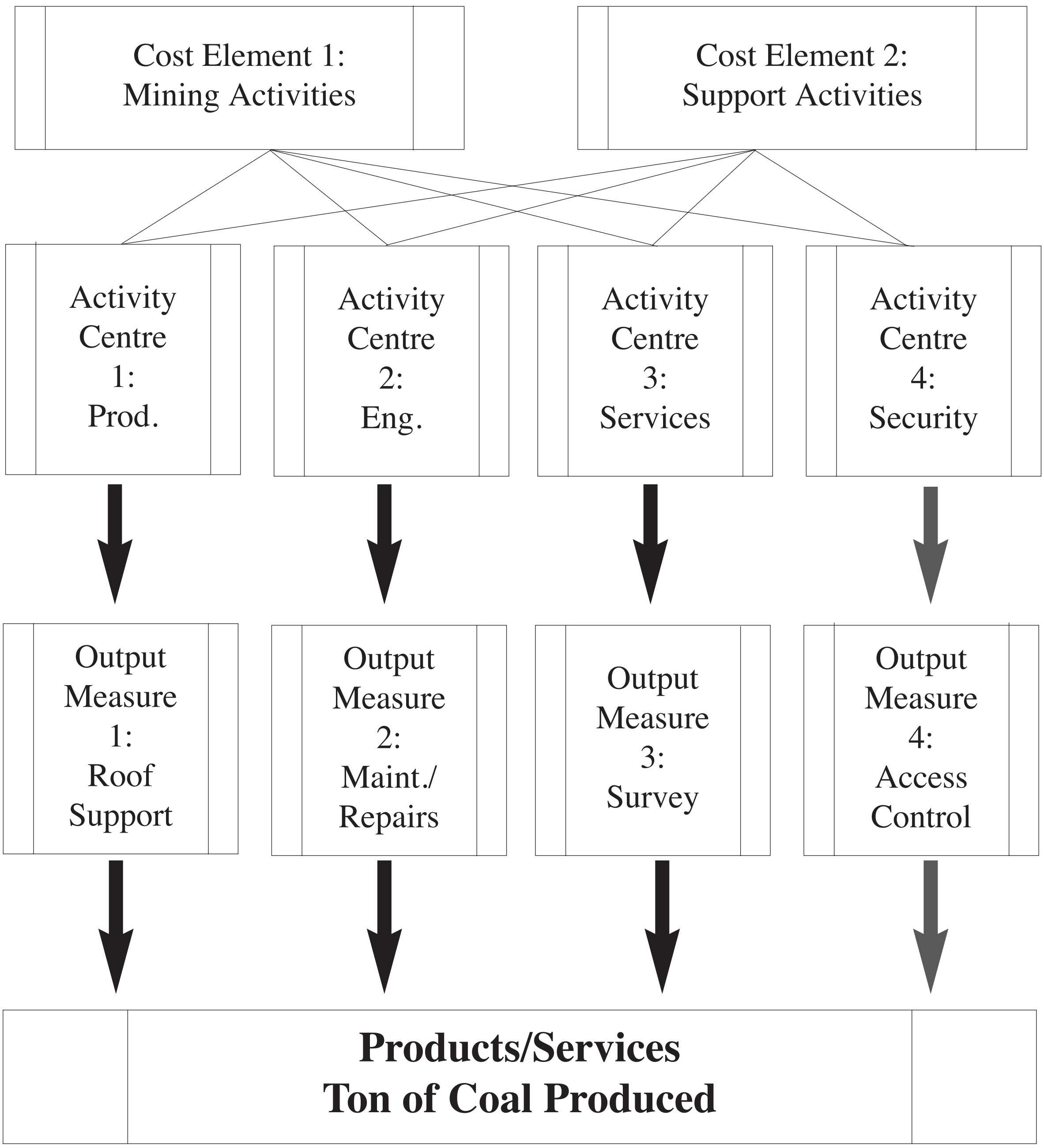

Figure 1—Simplified example of the Activity Based Costing (ABC) approach

cost of producing a ton of coal. These indirect costs now become a feature of the accounting process as they are no longer absorbed into other cost pools. Where these non-volume related costs are significant, ABC will have its largest benefits. ABC makes use of a sufficient number of indirect cost pools for analysis. Like traditional costing, ABC also uses a two-stage allocation of overhead costs. It pools the overhead costs, but differs from the traditional approach by combining overheads into a variety of activity-based cost centres that are directly coupled to outputs via a sequence of cost drivers, rather than a limited number of cost centres as in the traditional approach. ABC assigns overhead costs to a large number of cost pools that represent the most significant activities involved in the production process. Once these costs have been allocated to the activity pools, cost drivers are identified that are suitable for each pool, e.g. roof support is one function of the production activity centre in Figure 1). The overhead costs are assigned from each activity cost pool to each production job in proportion to the amount of the activity used up by that job (e.g. what proportion of access control of the security function at the mine was used to ensure that the ton of coal was produced). Hence, ABC assigns activity costs to cost objects based on activity drivers that accurately measures consumption of the activity.

Improved costing accuracy in ABC comes from identifying a large number of activity cost pools and the isolation of a suitable cost driver for each activity. Innes and Mitchell[5] are of the opinion that ABC provides a favourable environment for cost pool homogeneity and a cause/effect relationship between absorption bases and costs. ABC concentrates on managerial decision-making, ensuring that costs span the extent of the organization's direct and indirect activities, and focuses on the tracking of costs (Marx[6]). The author is thus of the opinion that an ABC approach would provide a better basis for decision-making based on the way in which ABC treats these costs.

Costs form a part of the decision-making process and cannot be used as a stand alone decision-making tool. For this reason, the author suggests making use of a framework he developed as a decision-making tool for underground mining systems. The framework incorporates thinking obtained from viewing costs as a holistic entity that cannot be used on its own to form a basis for decision making. Strategic Cost Management[7] (SCM) provided the thinking behind viewing costs as a strategic issue which lead to the development of the framework. Functional Costing[8] (FC) was previously employed as a costing alternative for underground coal mines and was consulted to further develop this new thinking. Life Cycle Costing[9] (LCC) suggested making use of the Net Present Value (NPV) approach to account for the use of the capital equipment. The LCC approach incorporated a tool into the framework that ensured that the cost of technology (capital) was accounted for over its lifetime. ABC eliminated the problem of the cross-subsidization of costs and ensured that specific costs (and not processes) were identified and was chosen as the superior costing tool for the framework. This framework is depicted in Figure 2.

The NPV method takes into account the time value of money. It involves estimating a project's future cash flows, discounting these cash flows at the company's required rate of return (cost of capital), and subtracting the cost of the investment from the present value. If the result is positive this indicates that the project results in an increase in shareholders' wealth as the project earns more than the required rate of return.

For the purpose of this analysis, the parameters suggested by Falconer (as described above) were used. In addition to the parameters suggested, a time frame of 15 years was placed on the expansion to account for usage of the equipment in terms of maintenance and replacement policy, with year-end conventions being followed. Since the productivity of these two mining systems has improved since Falconer's analyses, it was decided to increase the required tonnage per month to 300,000 tons. It was further assumed that either 4 continuous miner systems or 1 longwall system would achieve this result. A hypothetical decision on the type of equipment to be used had to be made, which was restricted to either one of these systems. For the continuous miner sections, it was calculated that the capital cost per section would be R6,55 million, with the total operating costs for the 4 sections equalling R25,21 million per year. The longwall system was calculated to have a capital cost of R76 million and a total operating cost of R26,01 million per year. These figures are based on an estimate of present day prices. A cost of capital for all the iterations in this exercise was assumed to be 24%.

As mentioned, Process Costing and other more traditional costing approaches, does not take into account the size of the investment, or whether the investment is a good one. For comparison purposes, Falconer's results were extrapolated and were inputted into the framework so as to provide a benchmark figure on which to base a comparison. The results obtained found that the continuous miner system had an NPV of R26 million and the longwall system an NPV of (–R12 million). These original results indicate that the continuous miner system is a better investment than would be the longwall system (based on these 1989 figures). This result follows the same trend as Falconer's initial Process Costing results whereby the continuous miner system was

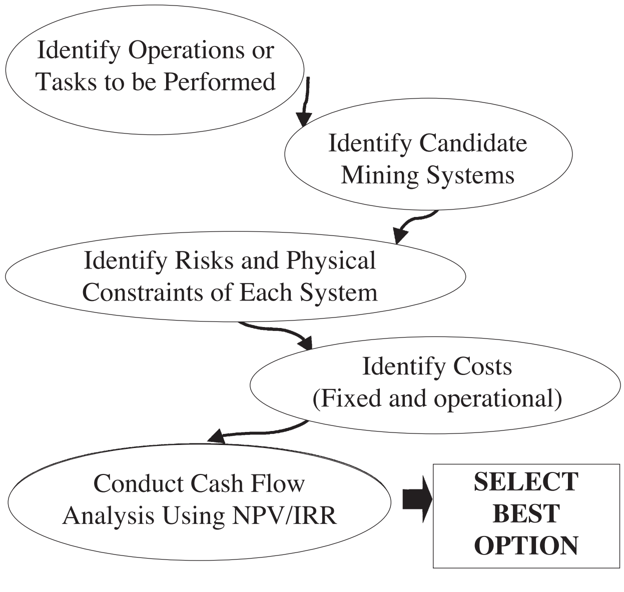

Figure 2—Decision making framework for capital investment decisions (after Lind[4])

less expensive on a Rand per ton of coal produced basis than the longwall system.

Having showed that the NPV analysis framework was suitable for this exercise (the results being congruent with the original work conducted by Falconer), current cost data (of both continuous miner and longwall systems) were obtained from an operating South African colliery, which uses both continuous miner and longwall mining systems, for input into the framework.

This process consisted of two steps. Firstly, the mine's cost data (which was in Process Costing format) was used to input into the NPV framework. The results obtained showed that the continuous miner system had an NPV of R111 million, and the longwall system an NPV of R81 million. Secondly, the same data were then subjected to an Activity Based Costing analysis, in a manner shown in Figure 3, to obtain the associated operating costs.

These ABC costs obtained were then inputted into the framework so as to obtain an equivalent basis on which to compare the two types of mining systems to the traditional costing approach. All other factors remained constant for this exercise, with only the operating costs obtained using ABC being different. The continuous miner system's NPV was R143 million and the longwall system's NPV was R97 million using the ABC approach.

What is the significance?

The results of the various techniques used to determine the return on investment using the various data (PC and ABC) is summarized in Table II.

In each of the cases presented above, the continuous miner system proved to be a better investment option. In terms of cost per ton as presented by Falconer, the continuous miner system was approximately R6 per ton less expensive than the longwall system. A re-evaluation of Falconer's data using the NPV-based framework clarified this point and thus showed that the results obtained from the analysis were consistent with the decision making results obtained from Falconer's work. On the re-evaluation of

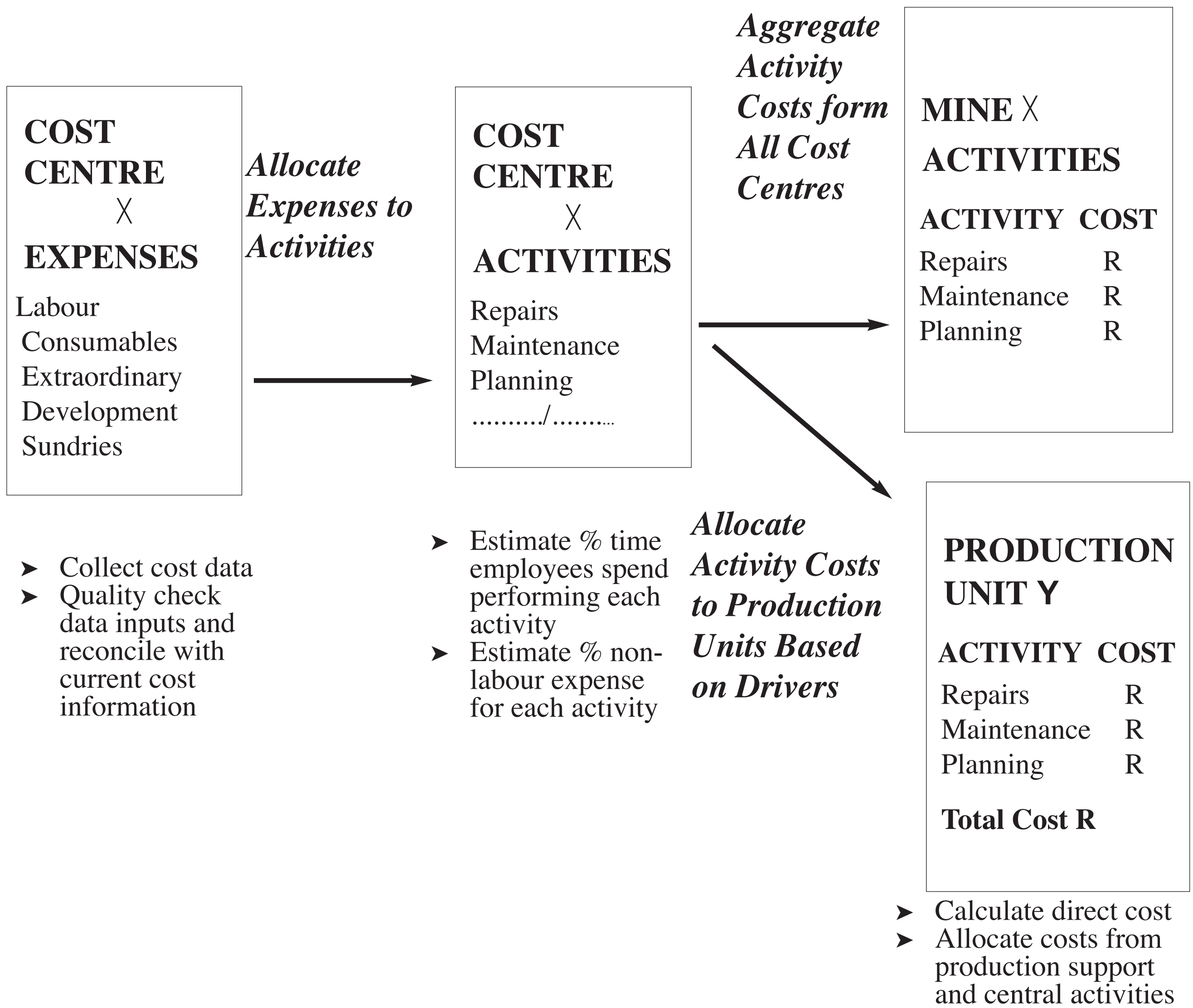

Figure 3—ABC methodology used to obtain costs

Table II

Summary of results

	Continuous miner	Longwall
Falconer's original Rand cost per ton	19,32	25,02
Falconer's original data inputted into framework NPV	R26,22 million	(-R12,38 million)
Validation data (process costing) inputted into framework NPV	R110,93 million	R80,53 million
Validation data (ABC) inputted into framework NPV	R142,81 million	R96,88 million

Falconer's results, the longwall system had a negative NPV at a cost of capital of 24%. Based on such an analysis one would have excluded the longwall system from the decision making process at that point in time.

When field data was obtained from an operating colliery for comparison purposes for the framework, a first pass based on the operating costs collected using the Process Costing technique suggested by Falconer again showed the continuous miner system to be a superior choice to the longwall system. The decision would be the same if made with the ABC approach. An important factor to note is that even with the operating costs being obtained using a different technique that the continuous miner system is a superior investment system over the longwall system.

One notices a drastic increase in the rankings of the individual systems when the ABC data are used. Presently, as opposed to when Falconer conducted his work in 1989, both continuous miner and longwall systems produce a higher tonnage. This is attributable to the increased productivity in the coal mining industry, as well as matured learning curves of the systems.

Activity Based Costing has been shown to be an accurate manner of obtaining the direct and indirect costs of a system. When ABC analysis was used, a lower operating cost was obtained for both the continuous miner and longwall systems. The effect this had on the final outcome was a significant increase in the NPV of both these systems. This stands to reason when observing Equation [1] that the lower the expenditure the greater the profit. The fact that the two techniques used gave vastly different results is of significance since ABC has accounted for both direct and indirect costs, while PC has taken the major cost centres to obtain its associated costs. ABC costs activities rather than processes, and this is an important factor of this analysis.

Another important factor to note is that either the ABC analysis underestimates the true cost of a system, or that Process Costing analysis overestimates the true cost of a system (seen by the marked differences in the NPV's of the respective costing techniques). The way in which ABC allocates and tracks costs is seen as being a superior costing technique by many authors. This leads one to a conclusion that it is the Process Costing approach that is overestimating the true cost of a system in this case. An increase in the NPV of approximately 22% in the case of the continuous miner system and an increase in the NPV of approximately 17% in the case of the longwall system are observed between the ABC method and the PC method.

Conclusions

Modern costing theory challenges the way in which we currently cost mining systems. This paper demonstrates that there are marked differences between two types of costing techniques, viz. Process Costing and Activity Based Costing. This author, as well as those referenced, shows Activity Based Costing to be a more appropriate and effective costing technique as opposed to Process Costing (which is the way coal mines in South Africa currently cost their operations). That PC tends to overestimate the true costs is an important conclusion. In this exercise, the NPVs (except one) were positive, which warrant those systems a good investment. In a marginal case, however, costing a system by PC means only may have led to a point where the NPV is negative and the system being shelved or disregarded completely. Costing the same system by means of ABC could see the said system to have a positive NPV.

This paper by no means suggests that Process Costing is the incorrect method of costing underground coal mining systems. It does though challenge the thinking behind how one can better cost these mining systems to get a more reflective financial position.

The cost benefit analyses presented does not prescribe that in every such decision a continuous miner system should be chosen above a longwall system. Although the continuous miner system is versatile, it may be in the mine's best interest to select a longwall system (based on favourable geology, rate of extraction, perceived increase in safety associated with this mining system, etc.). The production rates and abilities of the system may largely have been under- or over-estimated, and various iterations need to be conducted for more objective results under different circumstances.

Only one aspect of Activity Based Costing has been described here. ABC has far wider and more significant applications as a management reporting tool. Such applications are widely covered in other sources.

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