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Applicability of activity-based management system in coal mines – a case study of an underground coal mine

In a traditional system of costing, the costs of services and products are not accurate as overhead costs are allocated through cost centres or departments. On the other hand, activity-based costing purports to costing technique in which products or services are assigned costs on the basis of their consumption of resources caused by activities and provides effective tool for activity based management system (ABMS). The cost assignment is done on specific activities like planning, design, engineering, production or despatch and thereafter the activities in the value chain are associated with different products or services. The implementation of ABMS facilitates proper decision-making by management and result in improvement of business process in terms of effectiveness and efficiency. In other words, by the process of determination of the real cost of products and services by ABC methodology, it becomes easy to identify the products and services which are economically non-viable, break-even or economically viable. Eventually, the economic break-even point can be determined and thus it is possible to compare the different options and explore opportunities for cost control by strategic decision-making. Evidently, ABMS, in a business, endeavours to analyse the information base of activity-based costing and identifies activities in order to eliminate those which do not add to the useful value of the product and focus on those activities which contribute to useful value and support the improvement of product to satisfy the consumer demands. The paper attempts to examine the efficacy of activity-based management system in underground coal mine through case analysis of a selected operating coal mine in India. To determine the cost of mining, all activities in the mine are identified first. The available resources for the activities and actual consumption based on activity cost drivers have been determined by field investigation and analysis. The costs derived by ABC method and traditional system are compared and analysed for managerial decision-making. The case study unfolds non-value added activities and inadequate capacity of underground coal transportation entailing managerial action.

Keywords: *Activity-based costing; activity-based management system; coal mining; activity cost drivers.*

1. Introduction

Over the years, business models have been undergoing a rapid change due to fast pace of technological development, growing competition amidst challenges of environmental and social sustainability. In the current scenario, companies have to allocate large chunk of fund for innovation, research, development, automation etc. and thus increasing the share of indirect costs. Indirect costs or overheads are to be apportioned traditionally by volume related drivers, which does not give the accurate cost of products or services. The activity-based costing (ABC) is a costing methodology in which activities are identified and assigned the costs on the basis of the consumption of resources. The costs of services and products are not accurate in traditional system of costing as the overhead costs are allocated through cost centres or departments or units on arbitrary basis such as direct labour (Walker, 1999). Based on accurate information on cost obtained by activity-based costing, the activity-based management system (ABMS) provides the most effective technique for managing cost. In fact, ABMS focuses on the management of activities and thus endeavours not only to value addition of the product but also the profit achieved by providing this value. ABMS involves activity analysis, activity cost analysis and activity-based costing (Gosselin, 1997). The activity analysis is analysed for each and every activity after identifying them in the value chain which are then subjected to cost analysis after selecting cost drivers. Thus, activity-based costing purports to costing technique in which products or services are assigned on the bases of their consumption of resources caused by activities (Blocher et al., 1999). Cost assignment is done on specific activities like planning, design, engineering, production or despatch and thereafter the activities in the value chain are associated with different products or services. The implementation of ABMS facilitates proper decision-making by management and

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result in improvement of business process in terms of effectiveness and efficiency. In other words, by the process of determination of the real cost of products and services by ABC methodology, it becomes easy to identify the products and services which are economically non-viable, break-even or economically viable. Eventually, the economic break-even point can be determined and thus it is possible to compare the different options and explore opportunities for cost control by strategic decision-making. Evidently, ABMS, in a business, endeavours to analyse the information base of activity-based costing and identifies activities to eliminate those, which do not add to the useful value of the product and focus on those activities which contribute to useful value and support the improvement of product to satisfy the consumer demands.

India is on a high orbit growth trajectory, which calls for commensurate increase in energy demand. In India, 56% of primary commercial energy is met by coal alone. Around 73% of the entire power generated in the country is coal based. Even with focus on clean and renewable energy, coal with its abundance, availability and affordability is the preferred energy in India as on date and is likely to be so in the foreseeable future. With the growing importance of coal mining industry in Indian economy there is a need to revisit the mining sector with economic perspective. The economic, social and political scenario is constantly changing, the new paradigm of global competition calls for sustainable mining in an eco-friendly manner, which requires ability to innovate and improve in a cost-effective manner. Over the last decade, cost of coal mining in India especially underground mining has gone high. Barring a few mines, all underground mines of Coal India Limited are incurring losses and the company had to close several operating mines during last two years.

It is pertinent to mention here that after the advent of the concepts of ABC, several studies have been undertaken in different sectors including the coal mining sector. Lind (2001) studied the cost of coal mining in South African mines by longwall and continuous miner system and demonstrated that ABC offer better and accurate costing than traditional process costing and can be relied for making best practice decision. Further, a detailed case study of Eshidiya mine belonging to Jordan Phosphate Mines Company was done by Abdullah and Irshaidat, 2009. ABC model is developed after combining different activities under sub-models, which revealed that implementation of ABC method would increase the customer value by reducing cost, which is triggered by identification, and decrease of non-value added activates. Mariana and Boca (2012) studied the cost of mining in extractive industry of Romania by identifying direct and indirect cost, activities and cost drivers and compared the cost per tonne with traditional costing method. It is inferred that ABC emphasizes on the actual behaviour of costs and in the process, identifies the non-value added activities. The authors have tried to establish that these methods can lead to reduction in cost and providing real and timely information to the management of mining entity to enable decision with long-term positive impact. Though, the studies are quite relevant but may not be of direct use in view of altogether different mining systems and business models in India. So far no study on ABC has been undertaken in Indian mining sector nor has it been ever tried in mines in India. In view of growing concern for survival and sustainability of coal mining sector especially underground mining, it is imperative to study the cost of mining in an underground coal mine and suggest the measures to control it. In this context, the activity-based management provides the most effective technique for measuring and managing cost. The whole gamut of mining operations right from mine to market is viewed more microscopically scanning each activities and task within the activities from economic point of view as to whether it is contributing to the value of the product or adding to the expenses.

Keeping in view the role of coal in energy security of the country, the cost-effective mining of coal is of paramount importance in the current scenario. As such, the selection of topic for study is right and relevant in the present situation and shall be of immense use to mine developers and operators of the country. The paper endeavours to identify the number of activities in an underground mine through case study and determine the real cost of production of coal based on activity-based costing. It is seen that all the activities are not utilised for production and some of them are non-value added activities, which need to be phased out and eliminated. Similarly, the resources pressed into service for different activities are too, not fully utilised resulting in unused or excess capacity. It is demonstrated by the case study that the cost of mining in an underground mine can be considerably reduced if activity-based management system is applied and managerial actions are taken for eliminating non-value added activities and excess resources.

2. Literature review

The activity-based costing was first advanced by Cooper and Kaplan (1988) who asserted that ABC approach endeavours to capture the economics of the various processes of production more closely than traditional method thus provides more accurate cost data. According to Carolfi (1996), activity-based costing system enables us to segregate the value-added activities with non-value added activities in the organisation and know their associated costs after recognising the drivers of the activity costs. Based on the information obtained through activity-based costing, managerial action can be initiated by re-visiting the products and services that consume lesser and less costly resources, enhancing the efficiency of existing activities, eliminating such activities, that is non-value adding apart from enhancing the quality improvement measures by identifying the activities causing poor quality. The improvement in financial parameters

attributable to activity-based costing and conditions, conducive to such improvement was studied by Marinus and Bouwman (2002). The authors have applied statistical technique like confirmatory factor analysis and structural equation modelling to investigate the relationship between ABC and financial parameters for performance assessment. Anand (2004) studied 53 Indian firms, out of which 26 firms who responded during the survey were found to have adopted activity-based costing for pricing of the product and operational feedback. It was revealed that firms, which were using ABCM (Activity-Based Cost Management), had an added advantage of capturing accurate cost information useful for value chain analysis and supply chain analysis. The main motive for implementation of activity-based costing in Indian firms was to have detailed information on value-added and non-value added activities in the firms. Moreover, there was an urgent need to be competitive in the industry in terms of price, quality and performance. Kren (2008) while investigating the loan processing cost at Lakeside Bank found that ABM provides effective tool not only for cost control by identifying and eliminating non-value added activities but also capacity management. He further concluded ABMS could be applied at the time of planning stage to recognize cost of excess capacity while identifying non-value added activities. During the period of operation, ABMS can be applied to develop explicit cost reduction initiatives. As referred earlier, some of the studies relating to ABC have been conducted in coal mining sector. One study by Lind (2001) revealed that ABC offer better and accurate costing than traditional process costing and are more reliable in decision-making. Further, the case study on Jordan Phosphate Mines Company by Abdullah and Irshaidat, 2009 in which ABC model was developed after combining different activities under sub-models. It is seen by the study that implementation of ABC method results in decrease of non-value added activities thereby increasing the customer value by reducing cost. Mariana and Boca (2012) concluded that ABC focuses on true behaviour of costs and helps to identify the non-value added activities which will result in cost reduction. There is no study in Indian mining sector.

3. Coal mining in India: methodology and mine systems

Mining is the extraction of mineral wealth by driving excavation from surface to the mineral deposits located based on geological investigation called prospecting and exploration. When the mineral deposits occur on surface or at shallow depth, excavation used for mining is open and operated from the surface, which is termed as surface mining. In case of deposits lying at depth below the earth's surface, underground mining is undertaken, in which approach is made through openings from surface of the earth for human entry and mineral evacuation. The basic step used for producing mineral from the deposit is the unit operations of mining.

The unit operations of mining consist of drilling, blasting, loading, hauling, transporting and despatch which is cyclic in nature. However, with adaptation of mechanisation and automation, some of the operations are combined as continuous operation. Coal mining in India dominates opencast mining. The share of production from underground mining, is declining gradually due to increasing losses and is barely 6%. The method of underground mining depends on the geo-mining conditions of the coal deposit and other considerations like capital investment etc. The semi-mechanised method with loading by side discharge loader (SDL) or loadhaul dumper (LHD) dominates in Indian underground coal mines. Only a few underground mines are fully mechanised where mining is done with the application of continuous miner, shuttle car or powered support longwall equipment.

As such the case selected is a typical semi-mechanised mine operated by SDL by departmental resources. In this method, unit operation of mining consists of various mining systems with sequential activities - drilling, blasting, loading by SDL, transport and despatch. All these operations along with ancillary/auxiliary operations are performed by mine work-persons who are paid as their designations and categories. The payment of wages and perks of work-persons in Indian coal mines are regulated by National Coal Wage Agreements (NCWA) which is periodically revised. The workload of different categories of workers are also standardized under NCWA. As it is labour-intensive industry, the wages cost forms the major component of cost of mining. Due to unscientific mining and other reasons, all the coal mines in India, barring a few exceptional cases, were nationalised in 1972-73. Like most of the other underground mines in India, this mine too is nationalised mine, taken over from erstwhile private mine operators and lack proper planning and design.

4. Mine profile of underground mine-X

The mine, X has been developed long back in bord and pillar method. Presently the mine consists of three production outlets, which produce an average of 514 tonnes of coal. With a total manpower of 1290, the output per man shifts (OMS) is only 0.52 tonne in the current financial year. The low OMS is due to low level of mechanisation. Coal is won by drilling and blasting; loading is done by side discharge loader (SDL), underground transport is by series of direct and endless haulages. The tubs loaded with coal are finally hauled up to surface by shafts. The existing system of costing in the mine is based on traditional approach. Cost sheet is generated on monthly basis based on the monthly expenditure on different heads incurred in the mine. Finally, cost sheet for the financial year is prepared based on the expenditure incurred in the financial year. However, the method to derive at the cost under a particular head is crude. For example, to derive at wages cost, all expenditure under salaries, wages and

perquisites of all the employees of the mine irrespective of their jobs or department paid in the year is considered to get the actual cost in absolute terms. The cost is divided by yearly production to arrive at cost per tonne. Similarly, power bills irrespective of the specific job or activity is considered as power cost of the mine. The cost of production of one tonne of coal by traditional method works out to be INR 7553 (Indian Rupee). Thus, the cost sheet accounts for all the expenditure incurred in the mine, but does not provide why and how the expenditure was incurred and hardly help in managerial decisions.

5. Research methodology for the study

Production of coal in an underground mine involves number of activities from coal extraction from coal deposit to despatch. Apart from the activities, which are directly involved in production process, there are several other activities which are ancillary but necessary for support of coal production. For example, ventilation of a underground mine will have to be maintained so that noxious and inflammable gases are diluted to permissible limit and work persons involved at all stages of main activities get fresh air and comfortable condition. Thus, the first task was to identify the mine activities and then segregate them into main activities and ancillary activities. Since each activity is accomplished by certain resources the next most important task is selecting activity cost drivers and assigning resource costs to different activities. Finally, the production of coal was determined by linking activity costs based on the consumption of resources.

6. Proposed ABC model for mine-X

To determine the accurate production cost on the basis of the resources consumed by the various activities involved in the production process, following procedures are followed in the case study:

1. Identifying activities
2. Selecting activity cost drivers for each activity
3. Determination of cost of resources available and actual consumed by the activity for production (value addition) thus identifying non-value added activities and resources and capacities underutilised or unutilised for managerial action.

6.1. Identifying activities in the mine-X

Activity is a homogeneous set of operations which fulfils the obligations of a compartment to achieve a product, either partially or fully, provide a service, accomplish a work for which one or more persons applies the specialised knowledge and skill by deploying other resources. It is characterized by achieving a value chain and in the process, certain types and amount of resources are consumed. All activities are inter-linked, and no activity is isolated within the company. In order to implement the activity-based costing, the company deemed as set of activities, which consume resources to add value to the product and thus it is able to satisfy internal and external customers of the company (Mariana, Radu, 2012). Table 1 gives the list of activities identified and grouped as main (primary) and ancillary (secondary).

6.2. Selecting activity cost drivers for each activity

The cost of an activity can be simply taken as cost of the resources consumed by the activity. Activity consumes resources such as manpower, material, power, capital etc. The amount of resources used by activity is important. If an employee spends his entire time in a particular type of activity, the cost of employee is assigned to that activity. But if a supervisory staff devotes 10% of his time for a particular activity, cost of that supervision allocated for the activity will

Table 1: List of activities in Mine X

Main (primary) activities		Ancillary (secondary) activities	
Acronym	Name of the activity	Acronym	Name of the activity
MA1	Coal winning operation	AA1	Supervision and management
MA2	Coal loading operation	AA2	Ventilation system including gas monitoring,
MA3	Face and trunk transportation	AA3	Extension of service lines- track, cable, pipeline, supports etc.
MA4	UG to surface transportation	AA4	Water management system-pumping,
MA5	Despatch	AA5	Repair and maintenance system including power supply, communication system, track line, equipment etc.
		AA6	Inventory management system – purchase, store including magazine for storage of explosive etc.
		AA7	Transport of material from yard to underground at work place like timber, rail, sleepers, belt, roof bolts and other consumables
		AA8	Workshop with various machine like lathe, milling, drilling etc for repair and maintenance work, carpentry work, mud pallet making etc
		AA9	Personnel and administration including ministerial staff, security, accounts, township administration etc.

Table 2: Resource component and cost driver

Acronym	Resource components	Cost driver
C1	Wages cost:	Manshifts
C2	Store cost	No/Kg
C3	Power cost	kWh
C4	Interest and depreciation for capital items	INR
C5	Social and welfare overhead/security expenses	manshifts
C6	Contractual work including purchase repair and workshop	INR
C7	Coal transportation, demurrage, penalty for underloading/overloading	Tonne
C8	Administrative charges-for area and company level expenses	INR

be limited to 10% only. The linkage between the activities and production of coal in our case is done by cost drivers. The cost driver may be defined as a factor that causes the activities costs (Maher et al., 2001). It is the quantity of resources consumed by an activity. The resources consumed in production of coal and their corresponding cost drivers is given in Table 2.

The methodology followed for determination of cost of various resource components in this case as per system followed in India is indicated in brief as follows:

(a) Wages cost

It is labour intensive industry and cost of wages constitute a major part of cost of production. Though each worker has been categorised as per National Coal Wage Agreement, average earning per man shift has been considered for determination of the wages cost per tonne.

Wages cost per tonne = Earnings per man shift/output per man shift

In this case, average earnings as per cost sheet in Rs 2910.20 per man shifts. For taking into account absenteeism, a factor of 0.81 has been considered based on the inputs provided by the mine management during the study.

(b) Store cost

Store cost consists of consumables like explosive, detonators, drill bits, drill rods, roof bolts, hydraulic oils, spares including fast moving items like hoses used in SDL, haulage clips, haulage wire ropes, lubricants etc. For each activity, certain items are consumed, and the value of total items consumed for the production process was determined and consumption per tonne derived.

(c) Power cost

Power consumption in kWh for different activities was determined for each machine based on its kW and operation time. Total cost of power consumption for each activity was determined.

(d) Interest and depreciation cost

For all capital items including P&M (plant and machinery) involved in different activities, depreciation and interest was determined in respect of equipment used in that activity. The rate of depreciation and interest is taken from the cost sheet and inputs from mine management.

(e) Social and welfare overhead/security forces

Social and welfare overhead and security expenses were being incurred in an area which does not add value to product or production of coal.

(f) Contractual work including purchase repair and workshop

The actual expenditure incurred on various activities identified are considered and added on the cost of the concerned activities.

(g) Coal transportation, demurrage, penalty for under loading/overloading:

Since the entire coal transportation cost is charged to consumer, it does not form the part of cost. However, demurrage, penalty on under loading or over loading of railway rakes has to be incurred by coal producer. This cost is due to mismanagement or poor efficiency and is totally avoidable.

(h) Administrative charges for area and company level expenses

As an overhead to apportion the expenses incurred at apex level like area office and company office which is fixed by the management of the company. It is suggested that the administrative charges may be recovered from opencast mines which are generally operating in high margin of profit.

6.3 Activity-wise resource cost analysis

The cost of each activity was determined by adopting the following steps:

i. For accomplishment of each activity, types of resources are identified. Altogether eight types of resources identified as is given in the last paragraph. For each activity, types of resources required are given in Table 3. To make it simple, all resources having different cost drivers like manshifts, numbers, weight in kg, kWh have been converted into INR for calculation of cost.
ii. The amount of different resources in terms of cost drivers are determined for one-day activity. Average output of production in terms of tonne of coal for one day is considered to determined resources consumed per tonne of output.
iii. The added activities and capacities/resources unutilised or underutilised are determine for management control and decision.

Actual cost of each of the activities are determined by detailed study of the mine and its operation is as given in the following paragraphs.

Table 3: Activity vis-à-vis resource requirements

Activity	Resources essential for the activity								Remarks
Resources consumed	C1	C2	C3	C4	C5	C6	C7	C8	
MA1	R*	R	R	R				R	
MA2	R	R	R	R				R	
MA3	R	R	R	R				R	
MA4	R	R	R	R				R	
MA5	R	R	R			R	R	R	
AA1	R							R	
AA2	R	R	R					R	
AA3	R	R	R	R				R	
AA4	R	R	R	R				R	
AA5	R	R	R			R		R	
AA6	R							R	
AA7	R		R					R	
AA8	R	R	R	R		R		R	
AA9	R	R	R	R	R			R	

*R: Required

6.2.1. Coal winning operation - MA1

Coal winning operation in mining which aims to obtain loose coal from underground face is done either manually by cyclic operation involving drilling, blasting and support or by mechanisation using continuous miner or bolter miner or shearer in longwall mining method. In the mine-X taken up for study where cyclic system is practiced, following operations/sub-activities involved in coal winning activity have been considered and cost of each sub-activity has been determined as given below:

i. Drilling:

- Wages cost or cost of manpower deployed: It is done by crew of 3 drillers. For 3 district and 3 shifts, 27 drillers are deployed. As it is a mine having first degree of gassiness, drillers can drill 100 shot holes per crew as per standard practice which would mean 900 shot holes in a day.
- Store cost: The consumption of drill rod and drill bit is involved in the operation.
- Power cost is incurred in operation of electric drill

ii. Blasting

- Wages cost or cot of manpower deployed: It is done by crew of 5 shot firers/explosive carriers. For 3 district and 3 shifts, 45 shot firers/explosive carriers are deployed. As it is a mine having first degree of gassiness, shot firers can blast 100 shot holes per crew which would mean 900 shot holes in a day.
- Store cost: The consumption of explosive, detonators, shot firing cable and mud-pallets is involved in the operation.
- Interest and depreciation for capital items like exploder, shot firer's tool etc

iii. Dressing and support

- Wages cost or cot of manpower deployed: roof bolters
- Store cost: roof bolts, cement capsules, timbers etc
- Power cost is incurred for roof bolting

6.2.2. Coal loading operation - MA2

Coal loading operation is done manually by loaders/ miners, SDL/LHD/continuous miner/armoured face conveyor (AFC) etc in mechanized operation. In this case, loading is done by side discharge loader. The resources and cost associated with this activity is:

- Manpower for operation and maintenance of SDL involving wages cost
- Consumables - hydraulic oil and hoses of different types
- Power consumption for running the motor of SDL
- Interest and depreciation of capital cost of equipment i. e. P&M-SDL and accessories
- Cost of spares
- Maintenance and repair cost

6.2.3. Face and trunk transportation - MA3

Face and section transportation of coal is done by direct haulage, endless haulage, chain conveyor, shuttle car, belt conveyor depending upon the suitability based on geo-mining condition and production capacity. In this case, the transportation of coal in face is done by rope haulages and resource and the cost involved are:

- Manpower for operation and maintenance of haulages involving wage cost
- Consumables - wire rope, POL (petrol oil lubricants) etc
- Power consumption for motor of haulages

- Interest and depreciation of capital cost of equipment i. e. P&M-rope haulages
- Cost of spares
- Maintenance and repair cost

6.2.4. UG to surface transportation - MA4

Coal transportation from underground to surface is done by tubs/skips which lifted by winding engine in case of vertical shaft. In case of inclines, either belt conveyor is installed or transportation of coal is done by endless/direct haulages. In this case, the transport is done by winding engine equipped with cages for mine cars. The cost of the resources involved is:

- Manpower for operation and maintenance of winding engine, banksman, on setter etc involving wage cost
- Consumables - wire rope, POL etc
- Power consumption for motor of winding engine
- Interest and depreciation of capital cost of equipment i. e. P&M-winding engines
- Cost of spares
- Maintenance and repair cost

6.2.5. Dispatch-MA5

After the coal is evacuated from the mine, it is despatched through coal handling plant/loading arrangement and resources involved in this activity are

- Manpower for operation and maintenance of coal handling plant involving wage cost
- Consumables - belt conveyors
- Power consumption for motor of belt conveyors
- Interest and depreciation of capital cost of equipment i. e. P&M-belt conveyors
- Cost of spares
- Maintenance and repair cost

Similarly, costs of all ancillary activities were determined after identifying the resources involved in the activities.

6.3. Cost of various activities and resource consumed

After identifying the resources corresponding to each activity as stated above, costing was done for various activities in the mine taking into consideration both direct and indirect costs as given in Table 4.

Since the ancillary activities are supporting the main activities for production of coal in the mine, cost of ancillary activities has been apportioned to main activities to the extent they are contributing to main activities. Activity wise apportionment of ancillary activities are shown in Table 5.

ABC systems should be developed in such a manner that it is possible to identify and separate unused capacity by ascertaining the excess of costs of resources supplied or available over the costs of resources used and (Cooper and Kaplan,1992). Since all the available resources in each of the activities are not fully utilised or consumed for production of coal as mine is not running in full capacity, resources available for each activity was analysed as to what extent it is consumed or utilised for production of coal. Some of activities were not contributing to production directly or indirectly and were grouped under non-value added activities. The exercise resulted in identification of resources actually consumed for the production and surplus resources or un-utilised or under-utilised capacity of the mine. Thus, the actual cost of mining was determined based on activity based costing which could be of immense use to management for

Table No 4: Activity-based costing based on available resources

Activity	Cost of resources								Total cost of available resources
	C1	C2	C3	C4	C5	C6	C7	C8	
MA1	686	66	2	4				29.3	787
MA2	540	24	28	30				29.3	651
MA3	939	5	10	3				29.3	986
MA4	434	5	5	3				29.3	476
MA5	33	3	5			17	107	29.3	195
AA1	6							29.3	35
AA2	518	6	15					29.3	569
AA3	456	6	10	2				29.3	504
AA4	328	6	20	4				29.3	387
AA5	718	2	10			170		29.3	930
AA6	157							29.3	186
AA7	123		10					29.3	162
AA8	274	2	10	3		32		29.3	350
AA9	652	1	36	5	612			29.3	1335
Total	5864	126	161	54	612	219	107	410.0	7553

Table 5: Apportionment of cost of ancillary activities in main activities

Main activity		MA1	MA2	MA3	MA4	MA5	Total cost
Ancillary activity	Cost of resources	786	652	986	476	195	
Additional cost of resources accruing on account of role of ancillary activities							
AA1	%	30	20	20	10	20	100
	Rs	10.5	7	7	3.5	7	35
AA2	%	40	30	20	10		100
	Rs	227.6	170.7	113.8	56.9		569
AA3	%	40	30	30			100
	Rs	201.6	151.2	151.2	0		504
AA4	%	40	40	20			100
	Rs	154.8	154.8	77.4			387
AA5	%	10	40	30	20		100
	Rs	93	372	279	186		930
AA6	%	20	20	20	20	20	100
	Rs	37.2	37.2	37.2	37.2	37.2	186
AA7	%	40	40	20			100
	Rs	64.8	64.8	32.4			162
AA8	%	20	40	30	10		100
	Rs	70	140	105	35		350
AA9	%	20	20	20	20	20	100
	Rs	267	267	267	267	267	1335
Total Cost, INR		1913	2017	2056	1062	506	7553

taking decision in making this mine cost effective. Further, an exercise was done to calculate the benchmarking cost or standard cost for the level of mechanisation in the mine. For this, expert opinion was taken from top management officials of Bharat Coking Coal Limited, Central Mine Planning and Design Institute Limited, Tata Steel Limited (operating captive coal mines) and Professors of Indian Institute of Technology (Indian School of Mines). Based on the expert opinion, production potentiality of the mine was identified taking standard norms and benchmarking cost was determined. The results of the analysis and costing are given in Table 6.

6.4. Analysis of the results

It can be seen from the above study that there is substantial difference between the actual cost per tonne of coal production and cost obtained by accounting by traditional system of costing. The cost per tonne as per cost sheet is Rs.7553 but the actual cost based on activity based costing reveal that cost per tonne is as low as Rs.3084. Actually, resources allocated for different activities in the mine under study are more than what is required. In other words, though resources have been pressed to service, but the production is low resulting in under-utilisation of resources. In the investigation, the idle capacities and unutilised resources in each activity have been identified. Some of the activities have been identified as non-value adding. One such activity is in loading railway wagons at poor rate causing detention of wagons thus incurring demurrage charges. Under repair and maintenance head, 150 persons have been deployed which is surplus and a large part of this resources are being engaged in non-value added activities like gardening, cleaning, catering etc. in colonies and recreation clubs. Even in surface workshop, persons are much more that the machines in operation and the surplus manpower is not gainfully utilised rather engaged in non-value added activities.

Further, there are 6 workers' colonies spread in around the mine which are thickly populated. Hardly 10% of the employees of this mine are residing in these colonies but entire maintenance-electric supply, water supply, civil work etc. is maintained by the mine resources of the mine-X. This also clearly reflects the deployment of resources in non-value added activities. The non-value added activities can well be eliminated thus saving INR 1608. It can be seen from the Table 6 that unutilised and under-utilisation of resources are found in all the activities. The highest cost of resources unutilised is on 'Face and trunk transportation'. The mine is not able to operate at its full capacity due to bottleneck in the face and trunk transportation system. However, the capacity to load is as high as 1000 tonnes, evacuation capacity in trunk transportation system of the mine by direct haulage and vertical transportation by winding engine is very low and limits the production evacuation to almost half of the capacities in other operations. The share of manpower cost is about 78% of the total cost of resources. The surplus

Table 6: Cost per tonne of coal production based on activity-based costing

	Activity	Total activity cost as per available resources	Non-value adding activity or part	Additional resources/ capacity unutilised or underutilised	Actual cost for the production of coal per tonne as per ABC	Benchmarking cost based on expert opinion after removing bottlenecks
1	MA1	786	0	365	421	337
2	MA2	652	0	303	349	279
3	MA3	986	0	458	528	422
4	MA4	476	0	221	255	204
5	MA5	195	107	41	47	83
6	AA1	35	0	16	19	15
7	AA2	569	0	265	304	244
8	AA3	504	0	234	270	216
9	AA4	387	0	180	207	166
10	AA5	930	523	231	176	398
11	AA6	186	0	86	100	80
12	AA7	162	0	75	87	69
13	AA8	350	82	80	188	150

manpower i.e. unutilised or underutilised manpower which is reflected in poor OMS of 0.52, appears to be main reason for high cost of production. It can be seen from the table that in every activity, the resources are not fully consumed for production resulting in surplus resources amounting to INR 2861. It is suggested that the transportation system need to be strengthened to cope up the loading capacity of SDLs which will result in production capacity of more than 1000 tonnes, almost double of what is being achieved as on date and result in drastic reduction of cost of production with optimum utilisation of resources.

This can be further seen in this case that administrative cost of Rs 410 has been loaded uniformly in all the activities for adjustment of expenditure incurred at various hierarchical level of administration. This cost can, too, be reduced if not eliminated by charging these costs in opencast mines, which are operating with high profit margin. The reason for the high cost of resources in the mine is due to the fact that huge unproductive resources especially work persons have been inherited by the mine from erstwhile mine operators.

There are two options to reducing cost in this scenario. One can reduce the resources limited to need based only but this has limitations. For example, manpower is a committed resource and is provided in the mine in advance whether they are fully utilised or not. The other option is to utilise the whole resources in the activities by increasing the volume of production. Production can be improved by having a matching system of coal evacuation in the mine. It is pertinent to mention here that the exercise has been done taking some assumptions, which may not hold perfectly in all the mines.

Benchmarking cost is derived considering international norms of productivity supported by expert opinion and was found to be lower than the actual cost of mining derived by activity based costing. This exercise, if done for any mine can be a management tool for knowing the actual cost scenario of mining and taking decision for better, effective and efficient cost performance.

7. Conclusions

The case study of the underground mine explicitly reveals that activity-based costing is more accurate and appropriate technique for deriving unit cost of production as opposed to traditional costing methods. The traditional cost tends to overestimate the true cost of production in mining industry and does not provide valuable input for management control. On the other hand, activity based costing model gives insights to management to understand the cost components of the mine from the process perspective in order to determine the true value of product. The extent to which resources available match with resources required for production giving an idea of how much the surplus resources can be eliminated or diverted for other productive activity else used for enhancing production of the mine thus reducing per tonne cost. In this case study, certain non-value added activities have been identified which are demurrage charge for delay in loading railway wagons, work-person doing work not related to or contributing to production or not at all working. The financial impact of the non-value added activity works out to be very high. By applying ABC in this case, it has been shown that not only the activities which is contributing to value chain could be measured but also the identifies and quantifies resources going into waste in different activities. It has also been seen that the due to bottleneck of the system i.e. mismatch of transportation and loading system in coal production, the resources in all the activities appear to be surplus. The only wayout is to remove the bottleneck of the system for augmentation of coal production by replacing

existing haulage system by belt conveyor system or other suitable system for coal transportation and achieve optimum level of production wherein entire available resources are utilised. Based on the above inputs, managerial actions can be taken in the mine which will definitely bring about drastic improvement in cost performance of the mine. It is concluded that activity-based costing model can be effectively used not only for pinpointing the exact problems and bottlenecks of the mine but also quantifying the intensity and extent of the problems so that suitable managerial action can be taken to improve the system. Thus, activity based management system can go a long way in improving the cost performance of the various coal mines which appear to be economically unviable but have high potential for improvement.

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CHARACTERISTICS OF VIBRATION AT FAILURE AND ITS RELATION TO ROCK PROPERTIES DURING TENSILE FAILURE

(Continued from page 119)

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