ISSN: 0976-3376

Available Online at http://www.journalajst.com

ASIAN JOURNAL OF SCIENCE AND TECHNOLOGY

Asian Journal of Science and Technology
Vol. 08, Issue, 09, pp.5511-5516, September, 2017

RESEARCH ARTICLE

ASSESSMENT OF COMPARATIVE OPERATING COST OF NEW DRAGLINE VS. OUTLIVE DRAGLINE

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ARTICLE INFO

Article History:
Received 27th June, 2017
Received in revised form
17th July, 2017
Accepted 21st August, 2017
Published online 15th September, 2017

Key words:

Dragline, Operating cost,
Ownership cost, Overawing,
Overburden.

ABSTRACT

Economic exploitation of coal now a days is very indispensable. Cost and economics play a crucial role in deciding the financial profit for an organisation. Proper planning and selection of equipment considerably affects total revenue generated by mine. Draglines are the most expensive surface mining equipment which have been abundantly used in surface mine operation and civil engineering for decades. They are versatile and provide an efficient mining method in terms of cost and economics to remove overburden. High percentage of availability and utilizationis very essentialin order to achieve high production and productivity of draglines in opencast mines. The present paper mainly focuses on the importance of economic assessment of dragline productivity parameters such as cycle time, swing angle, seating position, availability, utilization etc [1]. In this contest, calculation of operating cost of new dragline operation has been done and compared with the outlive dragline which is presently working in many of opencast mines in India. A case study has been included for providing a better understanding of cost and economics involved in newer dragline and outlive dragline operation. For this data has been collected from opencast mine where draglines have been deployed for removal of overburden for fast rate of coal exposure.

INTRODUCTION

In India, 639.234 MT coal was produced in financial year 2016–17and the overall production of coal for 2017-18 was projected at 724.71 MT [Data collected from Provisional Coal Statistics of India in 2015-16]. About 90 % of coal is being produced from opencast mines and rest from underground mines.Opencast mines deploy large number of state of the art Heavy Earth Moving Machines like Draglines, BWE and Shovels-Dumpers combination to remove overburden etc. Draglines are the largest mobile equipment in the earth which remains the choice wherever geo-mining condition permits because of their high production versatility and low cost per unit moved. Dragline is called "Kingpin" of any mining site because of its high capacity and capital cost [Sahu and Naik, 2004]. They are required to be used in most efficient manner to get the return from the investment and achieve desired coal production target of the country. There are 50 draglines operating in India among which 4 draglines are dismantled due to overage. About 22 draglines are working in Northern Coalfields Limited. Another 3 draglines are under erection at Singrauli Coalfields. As such, Singrauli Coalfields alone will handle nearly 70% of the total country's Dragline output [Kishore Nawal, 2004].

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Walking draglines are the most popular machine for removal of overburden due to their flexibility, utility and availability as well as their low operating costs for overburden removal. The dragline is a typical cyclic excavator and material carrier which can excavates material and dumps it without the use of auxiliary transportation such as dumpers, conveyor belts (Vidyasagar *et al*., 2016). The dragline sits above the blasted overburden block generally known as Bench height usually 50 to 60 m wide, as a cut width on the high wall side and removes the material in front of itself and to dump it towards decoaled area. The ultimate goal of dragline operation is to be maximise the rate of coal exposure at the lowest unit cost. The rate of coal exposure is influenced by bench height, cut width, seam thickness, rehandling percentage on which it sits (Mohammadi M. et al., 2015). A proper planning is the pre-requisite process which enable to achieve the desired production rate and hence forth in terms of cost and economics. The present paper discuss to estimate the operating cost of new dragline and compare its coast and economics with the outlive draglines which are presently working in some of opencast mines in India for better understanding regarding operational cost of draglines in prevailing condition. The total population of draglines working presently in Indian opencast coal mines are given in Table 1.

Table 1. No. of draglines operating in India [4]

Company	Project	Dragline Specification	Numbers
BCCL (CIL)	Block II	24/96	1
BCCL(CIL)	Joyrampur	5/45	1
ECL(CIL)	Sonepur Bazari	26/82	1
MCL(CIL)	Balanda	4/45,10/60, 11.5, 20/90	4
MCL(CIL)	Belpahar	10/70	1
MCL(CIL)	Lajkura	10/70	1
MCL(CIL)	Samaleshwari	10/70	1
NCL(CIL)	Amlori	24/96	3
NCL(CIL)	Bina	10/70-2 nos., 24/96- 2 nos	4
NCL(CIL)	Dudhichua	24/96 – 4 nos.	4
NCL(CIL)	Jayant	15/90 -1 no., 24/96 -3 nos.	4
NCL(CIL)	Khadia	20/90 – 2 nos.	2
NCL(CIL)	Nigahi	20/90 – 2 nos., 24/96 – 2 nos.	4
NCL(CIL)	Krishnashila	33/70	1
SECL (CIL)	Bisrampur	30/76 – 2 nos.	2
SECL(CIL)	Chirimiri	10/70	1
SECL (CIL)	Dhanpuri	10/70 -1no., 20/90 -1 no.	2
SECL(CIL)	Dola/Rajnagar	10/70	1
SECL (CIL)	Jamuna	5/45 -1 no. , 10/70 – 1 no.	2
SECL(CIL)	Kurasia	5/45 -1no.,10/70 -1no., 11.5 -1no	3
WCL(CIL)	Ghughus	24/96	1
WCL(CIL)	Sasti	20/90	1
WCL(CIL)	Umrer	4/45 -1no., 7cum- 1no., 15/90 - 1 no.	3
SASAN (RELIANCE)	Singrauli	62/100	2

Table 2. Average thickness, Gradient, Grade and Specific gravity of workable coal seam of Jayant mine

Seams	Average thickness (m)	Gradient (deg.)	Grade	Specific gravity
Purewa top	7	2 – 4	F - G	1.60
Purewa bottom	10	1 – 4	E - F	1.56
Turra seam	18	1 – 3	C - D	1.52

Table 3. Description of lithology of Jayant mine

Particulars	Thickness (m)
Top soil	0.00 - 3.00
Sandstone and shales above the Purewa top seam	12 -95
Purewa top seam	2.62 - 8.79
Sandstone parting between Purewa top and bottom seam	17 - 32
Purewa bottom seam	5.98 - 12.66
Sandstones between Purewa bottom and Turra seam	52 - 59
Turra seam	13.30 - 20.30
Sandstones below Turra seam	+30

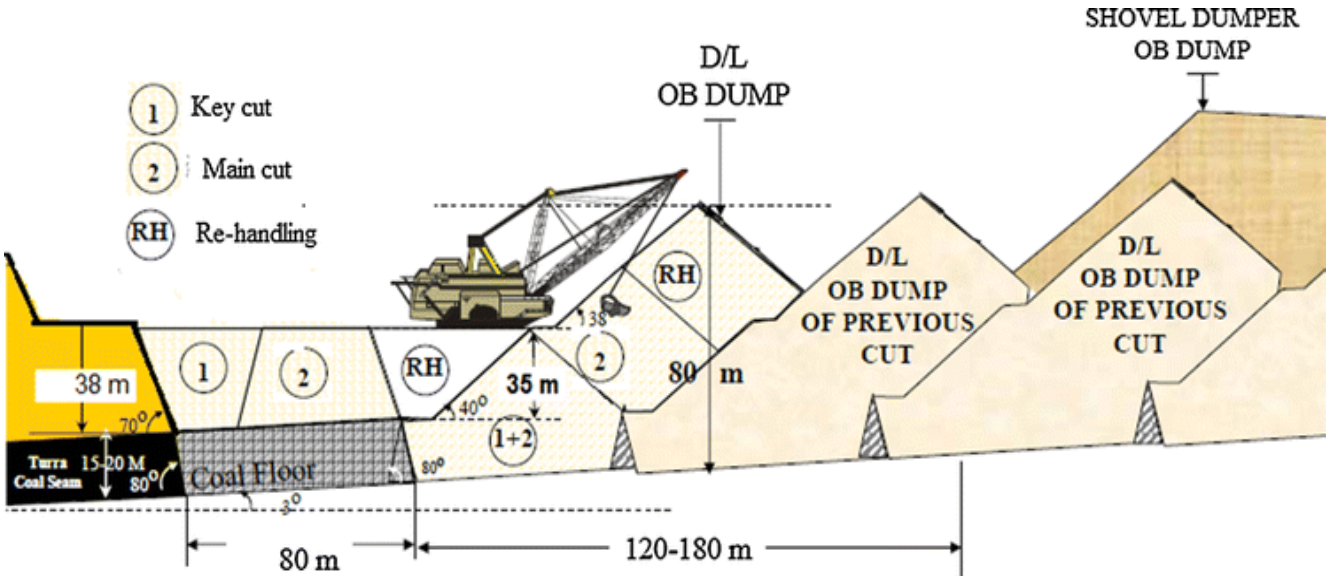

Fig. 1. Schematic diagram of dragline operation

Case Study

A case study has been carried out in Jayantopencast mine for comparing the cost of new dragline and outlive dragline which is working presently. Jayant mine is one of the largest coal mine of India in terms of total annual excavation volume as well as in terms of coal production. The mine falls in the Singrauli Coalfields where the rocks are of Gondwana formation having coal bearing Barakars within it. The project is mainly linked to Singrauli Super Thermal Power Station. The coal is generally of poor quality with the grades varying from C to G having lease area and quarry area 24.64 km^2 and 9.6 km^2 respectively. Total reserves of the Jayant mine is about 348.90 Mte and overburden to be removed is 907 Mm^3 with an average stripping ratio of 0.385 cum/t. Rated capacity of coal production is approximately 10 Mte and overburden removal target is about 26 Mm^3. Life of mine is estimated to be around 35 years. Capital cost of Jayant mine is Rs. 3750 million. Present manpower and ultimate manpower is nearly 2900 and 3050 respectively. The thickness range of various workable seams is shown in Table 2.

Geological Formation

The Jayant mine is located in the Sidhi district of Madhya Pradesh, India between 24°6′45″ to 24°11′15″ latitude and 82°36′40″ to 82°41′15″ longitude on a high plateau ranging from 300-500 m above MSL. In the block, the strike generally trends from E – W is observed. The dip generally varies from 1° to 3° due NE & NW direction. Overburden consists of 90% sandstone (fine to medium and coarse grained) gray and white in color. At some places, ferruginous sandstone of brown colour is encountered. The description of lithology is as shown in table 3. In this region, rainfall occurs including June to September but highest rainfall take place in the month of July. The temperature is relatively constant throughout the year with maximum rise in the temperature is observed in the month of May.

Mining method

The mine was opened with central access road thus dividing the property into East and West flanks. This is the main haul road for coal transportation from face. The central haul road is made along a fault passing across the strike in the middle of the property. Two by-pass entries are made to east and west flanks to establish transportation link from the central haul road. Presently mining operations at Jayant mine are being carried out in two sections viz. east and west by deploying 2 nos. of 24/96 draglines in east section and two draglines namely 24/96 and 15/90 in west section in tandem for sidecasting the main overburden bench to expose Turra seam (Lower most seam). In east section, two draglines of 24/96 are working in horizontal tandem for a stripping bench height of 35 m with average cut width of 90 m. In west section, two draglines of 24/96 and 15/90 are working in vertical tandem for stripping bench height of 42 m (upper bench is 14 m and lower bench is 28 m) with average cut width of 75 m. The remaining overburden above the dragline stripping bench is removed (advanced in one or two benches 9 to 15 m as per requirement) by use of 10 m^3 electric rope shovel in conjunction with 85 ton/120 ton rear dump trucks to expose Turra seam. The overburden removed by dragline is dumped in the decoaled area, whereas the overburden from the shovel benches are dumped on old dragline heaps at least two dragline cuts away from the existing cut. Coal winning from Turra seam is being done by 10 m^3 electric rope shovels upto a bench height of 15 m, working in conjunction with 85 ton rear dump trucks. Where the seam thickness is more than 15 m, the remaining thickness is extracted by 2.8 m^3 hydraulic backhoe. During side casting of overburden a coal rib upto roof level of coal seam is left for safety purpose and to avoid some extra rehandling.

Cost Calculation

Calculation of operating cost of new dragline 24/96 operation in Jayant mine

The following norms have been adopted for calculation purposes:

No. of annual working days = 300
No. of daily shifts = 3
Duration of each shift = 8 hours
Life of Dragline 24/96 in years = 25
No. of operators required for Dragline 24/96 in each shift = 1
No. of helper per shift = 1

The cost calculation have been made on the basis of general information provided by original equipment manufacturers (OEM) and mine management.

Operating and Ownership cost of new dragline 24/96

Let us consider the following conditions of Jayant mine,

Cost of Dragline 24/96 = Rs. 1800 million
Life of Dragline 24/96 = 25 years
Depreciation cost for 25 year i.e. annual flat rate of 4%

So, Annual Depreciation Cost = Rs. 1800 million /25 = Rs. 72.00 million

Average Annual cost of ownership of new dragline 24/96

Average annual investment of equipment = (n+1)/2n * cost of dragline 24/96

= Rs. ((25+1)/2*25) *1800

= Rs 936.00 million

Assuming annually interest, insurance and tax of the equipment is estimated at the rate of 12.5 %

= Rs. 12.5 % of 936.00 million

= Rs. 936.00 * 12.5 % million

= Rs. 117.00 million

Total ownership cost per year = Depreciation cost of equipment per year + cost associated with interest, insurance and taxes

= Rs. 72.00 + 117.00 million
= Rs. 189.00 million

Operating cost per year

Annual Manpower Cost (Salary and wages)

Six operators are operating the Dragline 24/96 in three working shift i.e. each 8 hours a day.

Operator Salary per month = Rs. 0.14 million/ operator/month
Operators monthly salary = Rs. 6 operator * 0.14 million
= Rs. 0.84 million
Operators annual salary = Rs. 0.84 *12 million
= Rs. 10.08 million

Helper cost @ Rs. 0.05 million/ month/helper

Total helper cost annually = Rs. 0.05 million/helper/month * 3helper /day*12 months
= Rs. 1.80 million

Total Manpower cost annually = annual operator cost + annual helper cost

= Rs. 10.08 + 1.80million
= Rs. 11.88 million

Annual power/energy consumption by Dragline 24/96 on the basis of 13.65 Mkwh

Annual power consumption cost @ 7.00/kwh

Annually energy consumption cost by Dragline

= Rs. 7.00*13.65 million
= Rs. 95.55 million

Annual lubrication cost (as per rule) = annual lubrication cost @ 30 % of the power consumption

= Rs. 30 % * 95.55 million
= Rs. 28.67 million

Annual maintenance cost

Routine maintenance cost = 20% of the depreciation cost annually

= Rs. 20 *72.00 million
= Rs. 14.40 million

Major breakdown maintenance cost @ 2% of cost of equipment

= Rs. 2 * 1800 /100
= Rs. 36.00 million

Total maintenance cost = Routine maintenance cost + Major breakdown maintenance cost

= Rs. 14.40+ 36.00 million
= Rs. 50.04 million

Total annual operating cost = Manpower cost per year + power consumption cost per year + Maintenance cost per year + Lubrication cost per year

= Rs. (11.88+ 95.55+ 50.40+ 28.67) million
= Rs. 186.50 million

Total annual ownership cost and operating cost = Annual ownership cost + Annual operating cost

= Rs. 189.00 + 186.50 million
= Rs. 375.50 million

Overburden removed by new dragline 24/96 in Jayant mine

By using formula (given as per CMPDIL norms)
Hourly production by Dragline

$P= (B*k*f*m*s*3600)/c$

Where,

B= bucket size (m^3)
K= availability cum utilization factor
F= bucket fill factor
M= machine travelling and positioning factor
S= swell factor
C= cycle time (sec)
Annual production = hourly production by dragline* 8760 days /annum (Mm^3)
Hourly production by dragline 24/96
B=24 m^3
K=0.73
F=0.933
M=0.75
S=0.719
C=80
P= (24*0.73*0.933*0.75*0.719*3600)/80
=31732.80/80
=396.66 m^3/ hour
Annually production by dragline 24/96 = Hourly production *8760 hours /annum
= 396.66 m^3/hour*8760
= 3.48 Mm^3

Calculation of cost per m^3 overburden removed by new dragline 24/96

Operating cost by dragline 24/96 in per m^3 of overburden= (total operating cost annually + total ownership cost of annually dragline)/ annual overburden removal by dragline in m^3

= Rs. 375.50 million/ 3.48 Mm^3
= Rs. 108.00/m^3

Though the mine has overall stripping ratio of approx. 1:6.7 but the effective stripping ratio for dragline 24/96 is vary from 1:1.3 to 1:1.5 (due to variation of overburden bench height and density of coal)

Assume, stripping ratio = 1.5 m^3/te

Then coal exposed by dragline 24/96 = (annually overburden removal by dragline 24/96)/stripping ratio

= Rs. 3.48 Mm^3/(1.5 m^3/te)
= Rs. 2.32 million te

Estimated Cost per tonne of coal exposed

= Rs. 375.50 million/2.32 million te
= Rs. 161.00 / te of coal exposed

Calculation of operating cost of Outlive dragline 24/96 operation in Jayant mine

Maintenance and overhauling cost of outlive dragline = □50 million
Cost of Outlive dragline 24/96 = □ 50 million
Life of Outlive dragline 24/96 = 10 years
Depreciation cost for 10 year i.e. annual flat rate of 4%
So, Annual Depreciation Cost = □ 50 million /10 = □ 5.00 million

Average Annual cost of ownership of outlive dragline 24/96

Average annual investment of equipment = (n+1)/2n * cost of dragline 24/96

= Rs. ((10+1)/2*10) *50
= Rs. 27.5 million

Assuming annually interest, insurance and tax of the equipment is estimated at the rate of 12.5 %

= 12.5% of Rs. 27.5 million
= Rs. 3.48 million

Total ownership cost per year = Depreciation cost of equipment per year + cost associated with interest, insurance and taxes

= Rs. 5.00+ 3.48 million
= Rs. 8.48 million

Operating cost per year

(a) Annual Manpower Cost (Salary and wages)

Six operators are operating the Dragline 24/96 in three working shift i.e. each 8 hours a day.

Operator Salary per month = Rs. 0.14 million/ operator/month
Operators monthly salary = Rs. 6 operator * 0.14 million
= Rs. 0.84 million
Operators annual salary = Rs. 0.84 *12 million
= Rs. 10.08 million

Helper cost @ Rs. 0.05 million/ month/helper

Total helper cost annually = Rs. 0.05 million/helper/month * 3helper /day*12 months
= Rs. 1.80 million

Total Manpower cost annually = annual operator cost + annual helper cost
= Rs. 10.08 + 1.80million
= Rs. 11.88 million

Annual power/energy consumption by Dragline 24/96 on the basis of 13.65 Mkwh

Annual power consumption cost @ Rs. 7.00/kwh

Annually energy consumption cost by Dragline

= Rs. 7.00*13.65 million
= Rs. 95.55 million

(c) Annual lubrication cost (as per rule) = annual lubrication cost @ 30 % of the power consumption

= 30 % * Rs. 95.55 million
= Rs. 28.67 million

Annual maintenance cost

Routine maintenance cost = 20% of the depreciation cost annually

= Rs. 20 * 5.00 million/100
= Rs. 1.00 million

Major breakdown maintenance cost @ 2% of cost of equipment

= Rs. 2 * 50 /100
= Rs. 1.00 million

Total maintenance cost = Routine maintenance cost + Major breakdown maintenance cost

= Rs. 1.00+ 1.00 million
= Rs. 2.00 million

Total annual operating cost = Manpower cost per year + power consumption cost per year + Maintenance cost per year + Lubrication cost per year

= Rs. (11.88+ 95.55+ 2.00+ 28.67) million
= Rs. 138.10 million

Total annual ownership cost and operating cost = Annual ownership cost + Annual operating cost

= Rs. (8.48+ 138.10) million
= Rs. 146.58 million

Overburden removed by Outlive Dragline 24/96

By using formula (given as per CMPDIL norms),
Annual production = hourly production by dragline* 8760days /annum (Mm^3)
Hourly production by dragline 24/96
B= 24 m^3
K= 0.73
F= 0.933
M= 0.75
S= 0.719
C= 90 sec
P= (24*0.73*0.933*0.75*0.719*3600)/90
= 31732.80/90
= 352.586 m^3/ hour

Annually production by dragline 24/96 = Hourly production *8760 hours /annum

= 352.586 m^3/hour*8760
= 3.088 Mm^3

RESULTS AND DISCUSSION

S.No.	New Dragline Operating cost	Outlive Dragline operating cost after revival/overhauling
1.	Cost of investment for procurement is Rs. 1800 million	Cost of investment in overhauling is Rs. 50 million
2.	Life of new dragline is 125000 working hours or 25 years as per norms by manufacturer	Life of overhauled dragline is 60000 working hours or 10 years approximately as per thumb rule
3.	Avg. cycle time of new dragline is 80 sec	Avg. cycle time of outlive dragline is 90 sec due to efficiency decrease in overhaul equipment by 10-15%.
4.	Cost of overburden removal by new dragline is Rs. 108/m^3	Cost of overburden removal by overhauled dragline is Rs. 47.47/ m^3
5.	Cost of coal exposure is Rs. 161/ te	Cost of coal exposure is Rs. 71.16/ te

Calculation of cost per m^3 overburden removed by Outlive dragline 24/96

Operating cost by dragline 24/96 in per m^3 of overburden= (total operating cost annually + total ownership cost of annually dragline)/ annual overburden removal by dragline in m^3

= Rs. 146.58 million/ 3.088 Mm^3
= Rs. 47.47/m^3

Assume, stripping ratio = 1.5 m^3/te

Then coal exposed by dragline 24/96 = (annually overburden removal by dragline 24/96)/stripping ratio

= 3.088 Mm^3/ (1.5 m^3/te)
= 2.06 million te

Estimated Cost per tonne of coal exposed = Rs. 146.58 million/2.06 million te

= Rs. 71.16/ te of coal exposed

Conclusion

It is wiser step to opt for overhauling the outlive dragline over procurement of new dragline. Investment on outlive is very economical as it involved almost one fourth of overhauling cost in contrast to newer dragline.

Operating cost, cost per m^3 of overburden removal as well as cost incurred in per tonne of coal exposed of outlive dragline is goes down while selecting outlive dragline relative to the new dragline. In case of 2 to 3 dismantled dragline in a mine, at least one dragline should be overhaul. The cycle time of overhaul dragline should be studied regularly and operating cost should be monitored during first year for better accuracy.

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