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Study of projection of annual output, ownership cost, operating cost and cost per tonne of coal exposed by dragline

Dragline system is a capital intensive, high capacity and specialized mining equipment. A dragline is a great piece of earthmoving equipment. This study reveals that dragline performance depends on reliability, availability and maintainability characteristics of the system and calculate the annual output cost, ownership cost, operating cost and cost per tonne of coal exposed. Productivity of dragline could be increased by decreasing the amount of rehandle, cycle time and idle time of the dragline. Failure in any of the components could cause entire dragline to cease. The downtime of dragline should be minimized to reduce the heavy pecuniary loss. Preventive maintenance should be made at the same time to decrease recurrence of failure and downtime cost. Dragline performance could be improved by decreasing the cycle time and idle hour losses and upgrading the maintenance strategies. It is essential that all the subsystems remain in operating state for the maximum possible time duration for efficient working of the dragline system. The evaluation showed that efficiency and projected production of dragline could be enhanced by improving utilization factor. Poor utilization resulted due to non-availability of blast muck, dozing operation, power and blast operations.

Keywords: *Dragline; preventive maintenance; reliability; availability.*

I. Introduction

Dragline has a very important role to be in enhancing the efficiency of coal mining. One of the most vital requirements of any dragline is to guarantee its higher availability. The higher availability of a dragline is depending upon higher reliability and maintainability of its component. The component of a dragon is however well designed, but will not perform satisfactorily unless they are appropriately maintained. Hence the overall objective of maintenance of the equipment is to make use the relevant information regarding failures and repairs. Therefore, critical mechanical subsystems with respect to failure frequency, reliability and maintainability of a typical dragline should be considered for taking necessary measures for enhancing its availability. The criticality of any system or subsystem in a typical drag line will be categorically studied under three main components as reliability, maintainability and availability. Coal is required in huge quantity. A considerable portion of coal is produced by adopting surface mining methods. To meet the demands of thermal, cement and other industry sectors the trend in production of coal has been increased. In order, to have high production with minimum cost, draglines are being used in coal mining. This equipment has been chosen because of its certain advantages like economically excavate deposits at greater and greater depth. Dragline is one of the surface mining equipment which is used to excavate materials and is designed so that it can excavate below the level of the machine also. Dragline working can be divided into two parts: Digging and walking. Among them walking is a steady process on which the mine design team has little control. The design of strip panels, equipping a specific unit with one operator's room on the desired side or with two on both sides and the management's strategy in coal loading operation largely affects the frequency and the length of long dead heading periods, during which the unit is unproductive. Now a days keeping in view of the demand of increasing productivity draglines having longer booms and large bucket capacity are being selected. However, to obtain low cost per cubic meter it is imperative to operate the dragline in a systematic manner for which constant supervision, good overburden preparation and preventive maintenance of dragline and selective proper bench height of overburden is very much required. In order to achieve higher coal production targets, it is necessary in order to remove large volumes of overburden in the shortest possible time and therefore it has been found that draglines are the best suited equipment to perform this type of work.

II. Methodology

Main objective of study are to determine the projection of annual output, calculation of ownership, operating cost and cost per tonne of coal exposed by dragline.

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A. Productivity factors of dragline

B. Mining parameters of an opencast mines

C. Evaluation of availability and utilization

To evaluate the availability (A) and utilization (U) the field data acquired was substituted in the equations (1) and (2)

$$A = [SSH-(MH + BH)]/SSH \quad ... \quad (1)$$

$$U = [SSH-(MH + BH+IH)/SSH \quad ... \quad (2)$$

where,

SSH is a scheduled shift hours,

MH is maintenance hours,

BH is breakdown hours,

IH is idle hours.

Based on the observed and recorded data in terms of average cycle time, A and U values the annual output (P1) of the dragline has been projected using equation (3)

$$P_1 = (B/C)*A*U*S*F*M*N_s*N_h*N_d*3600 \quad ... \quad (3)$$

where,

B is bucket capacity of the dragline in cubic meter

C is the average total cycle time of dragline in second

S is the swell factor

F is the fill factor

M is the machine travelling and positioning factor

N_s is the number of operating shifts in a day

N_h is the number of operating hours in a shift

N_d is the number of operating days in a year

D. The maximum depth of work

$$H= \{t + \tan x(R-W/4)\}/\{S + (\tan x/\tan y)\} \quad ... \quad (4)$$

where,

H is the maximum depth that can be worked by the dragline.

t is the thickness of coal seam

x is the angle of repose of overburden

R is the reach of dragline

S is the swell factor

W is the width of cut

y is the slope angle of highwall to horizontal.

E. Amount of rehandle (Prm)

$$Prm = [(1.125t + 0.684H + 0.1 R)/W] + [(0.25 t^2 -0.4Rt - 0.16R^2)/HW] + [(0.1t + 0.08R - 0.01W)/H] \quad ... \quad (5)$$

where,

Prm is the % amount of rehandle material

H is the overburden dump height

t is the thickness of coal seam

R is the reach of dragline

W is the width of cut

III. Analysis

By using the acquired data and recommended values in the Equations (3), (4) & (5), we get

- The projected annual output of the dragline is 2.87 M m^3
- The maximum depth that can be worked is 29.74 m
- The amount of rehandle percentage is 40.2%

A. Cost of ownership per year of the 24/96 dragline

(1) Cost of the 24/96 dragline = Rs. 1000 million

(2) Depreciation cost for 25 year i.e. annual flat rate of 4%

Annual depreciation cost of 24/96 dragline = Rs.40 million

(3) Average annual investment = [(N+1)/2N] * cost of dragline = Rs. [(26)/(2*25)]*1000 million = Rs. 520 million

(4) Annual interest, insurance rates and taxes i.e. annual flat rate of 12.5% = 12.5 % of Rs. 520 million = Rs. 65 million

Hence the total ownership cost per year = Annual cost + Annual interest = Rs. (40+65) million = Rs.105 million

B. Operating cost per year of the 24/96 dragline

(1) Annual manpower cost (salary and wages)

Operator cost is Rs.0.20 millions per operator for 2 operators in 3 shifts = Rs.1.20 million.

Helper cost is Rs.0.14 million for 1 operator in 3 shifts = Rs.0.42 million.

Total manpower cost = Rs. 1.62 million

(2) Annual power and energy consumption on the basis of 13.65 MKWH for 24/96

Annual power consumption cost is Rs. 4.89/KWH = Rs. $4.89*13.65*10^6$ = Rs.66.75 million

(3) Annual lubrication cost @ 30% of power consumption = Rs.20.025 million

(4) Annual maintenance cost @ 20% of depreciation cost = Rs. 8 million

Major breakdown cost @ 2% of cost of equipment = Rs. 20 million

Total maintenance cost = Rs.28 million

Hence, total annual operating cost = Manpower cost per year + Electrical cost per year + Maintenance cost per year + Lubrication cost per year = Rs.(1.62 + 66.75 + 20.025 +28) million = Rs.116.4 million.

Total ownership and operating cost = ownership cost per year + operating cost per year = Rs.(105+116.4) million = Rs.221.4 million.

Dragline operating cost per cubic meter overburden

Table I

Particulars	Recommended values
Swell factor (S)	0.719
Fill factor (F)	0.733
Machine travel and positioning factor (M)	0.8
No. of shifts in a day (Ns)	3
No. of hours in a day (Nh)	8
No. of days in a year (Nd)	365

Table II

Parameters	Details
Max operating radius (m)	88
Bench height (m)	30-35
Cutting width (m)	60
Highwall slope (degrees)	70
Bench slope (degrees)	60
Angle of repose (degrees)	38
Digging depth (m)	25
Reach of dragline (m)	73
Method of working	Extended bench method
Thickness of coal seam (m)	4.5
SSH (scheduled shift hour)	720
Working hours (WH)	507
Maintenance hours (MH)	119
Breakdown hours (BH)	33
Idle hours (IH)	61
Standard cycle time (s)	60
Observed cycle time (s)	61.7

handle considering annual output of 24/96 as 2.87 M m^3 = Rs. [(221.4*106)/(2.87*106)] = Rs.77.14.

C. Calculation of cost per tonne of coal exposed of dragline by extended bench method

Dragline deployed is 24/96 having a production capacity of 2.87 M m^3/year

Percentage rehandling is 40.2%

Total overburden handled = overburden directly over the exposed coal + overburden rehandled = overburden directly over the exposed coal (1+coefficient of rehandling)

Here, coefficient of rehandling = overburden rehandle/ overburden removal to expose coal

Therefore, 2.87 M m^3 = overburden directly over the exposed coal *1.402

Hence overburden directly over the exposed coal removed by the dragline = (2.87/1.402) M m^3 = 2.047 M m^3

Amount of coal exposure = (2.047 M m^3)/ (2.41 m^3/te) = 0.85 Mte

Estimated cost per tonne of coal exposed = Rs. (221.4*106)/ (0.85*106) = Rs. 260.47 = tonne of coal exposed.

IV. Result and discussion

- Annual output is Rs. 2.87 M m^3
- Annual ownership cost is Rs. 105 million
- Annual operating cost is Rs. 116.4 million
- Cost per tonne of coal exposed is Rs. 226.47

A. Factors affecting the production and cost of coal exposed by dragline

- Increased idle hours due to non-availability of blasted muck pile, operator availability, ability and performance.
- Increased breakdown time.
- Increased breakdown and maintenance costs.
- Improper supply of spare parts of dragline.

B. Scope for improvement of dragline performance

- Conditions assessment should be done in every five year.
- Retrofitting and replacing member and rope should be done in every five year.
- Damage and stability assessment should be done in every five year.
- Structure must look elegant, smart and fully functional.
- Increase the dragline productivity through maximizing cost by using blasting techniques.
- Strengthening of structure should be done with modern methods.
- Employing a spare dragline operator and reducing the variability in dragline operator performance.
- Better preventive maintenance schedule to reduce the breakdown time and breakdown costs.
- Coatings and protective coats must be applied to structures.
- Instability must be removed by balancing the structures for loads and configuration.
- All obstructions to be removed for smooth functioning and serviceability.

V. Conclusions

Draglines are very efficient, high productive excavating machines. We should get maximum output from these machines by adopting safe work practices. The trained manpower should be rotated among the similar mines, in order to gain fully utilize their training and expertise. Dragline structures are generally not maintained for serviceability. Some of the members are removed for the convenience and mining operation making structure unstable. Initial defects of fabrication of bolts, rivets are enlarged. Improper coating for protection of structure leads to corrosion of steel and reduction of properties of section environmental effects, mishandling of structure leads to deterioration of structures.

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