ISSN (e): 2250 – 3005 || Volume, 06 || Issue, 03||March – 2016 ||
International Journal of Computational Engineering Research (IJCER)

Maintenance and Performance Analysis of Draglines Used In Mines

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Abstract
A Dragline Is Surface Mining Equipment Which Is Used To Extract Coal By Removing Overburden. Its Performance Depends Upon The Maintainability; Availability And Reliability Characteristics Of The System. For Improving The Performance Of Draglines By Decreasing The Cycle Time, Ideal Time And Upgrade The Maintenance Strategies. Failures in Any Component Of Dragline And Improper Maintenance Could Cause Entire System To Cease. The Objective Is To Study The Performance And Maintenance Of Dragline. This Paper Also States That Immediate Improvement Has To Be Taken For Standards Of Dragline Performance.

Keywords: *Dragline, Maintenance of Dragline, Availability and Utilization Factor, Major*

I. Introduction

A Dragline Plays A Crucial Role In Coal Excavation. It Is Mostly Used In Open-Cast Coal Mines To Strip The Overburden Covering The Coal. When Coal Industry Started Using Draglines, Strategies Were Made For Maintenance And Initial Development By The Equipment Suppliers. Its Performance Mainly Depends On Maintainability, Availability And Reliability Characteristics Of System And Sub Systems Like Hoist, Swing, Boom And Others .If Any Failure Occurs In The Component Of Subsystem , It Results In Stoppage Of Dragline System [6]. Boom Failures, Rope Failures, Ring Gear And Pulleys Failures Are Major Breakdowns Of Dragline Which Occur Due To Improper Maintenance Of System [4]. This Study Discusses About Calculating The Annual Output And Ownership Cost, Maintenance Of Dragline. The Maintenance Strategies Are Mine Size, Productivity Requirements, Machinery Configuration And Economic Factors. The Maintenance Strategy Is Highly Dependent On The Initial Effort During Commencement Of Planning For Mining Operation. For Effective Operation Of Dragline There Should Be Constant Supervision, Good Overburden Preparation, And Preventive Maintenance Of Dragline And Selecting Proper Bench Height Of Overburden For Suitably Selected Machine. The Main Objectives Of This Study Are

a. Performance And Maintenance Of Dragline.
b. Calculate The Annual Output, Ownership And Operating Cost Of Dragline.

Dragline

Draglines Are Unique Pieces Of Equipment That Have Great History Of Evolution In Earthmoving Sector. Coal Is Mostly Available Homogeneous Raw Material In Earth Crust, And Also Mostly Used Fossil Fuels. Considering The Scale Of Extraction, Methods Are Highly Mechanized And Equipped With Huge Capacity. It Is Excessively Used In Coal Mining From Many Decades For Stripping And Coal .It Is Mostly Used For Handling Overburden Of Coal .It Is Largest Mobile Machine Ever Built. It Consists Of Large Bucket Which Is Suspended From A Boom With Wire Ropes. The Bucket Is Maneuvered By Means Of Ropes And Chains. The Hoist Rope Is Powered By Electric Motors And Drag Rope Is Used To Draw Bucket Horizontally. It Is Comprised With Multiple Electrical And Mechanical Systems Which Allow Digging And Dumping Cycles.

Conditions for Operation of Dragline

a. Gradients Should Be Flatter Than 1 In 6.
b. Seams Must Be Free Of Faults & Any Other Geological Disturbances
c. Deposits Have To Be With Major Strike Length.
d. Thick Seams With More Than 25m Thickness Are Unsuitable.
e. A Hilly Property Is Unsuitable.

1. Maintenance

Their Strategy Of Maintenance Depends On Mine Sites, Numbers Of Draglines Used On Site And Their Operating Conditions. It Is More Advantageous When Compared To Alternative Strip Mining Methods Because It Can Efficiently Handle Very Large Volumes Of Material. In Quarrying Operations A Great Force Exerts On Machine By Opencast Mining Operations, There Is Great Importance For Machine Maintenance And Availability. Better Maintenance Results In Better Availability Of Machines Which In Turn Contributes For Better Production. Better Maintenance Is Not Simply Implementation Of Maintenance Schedules And Carrying Out Repairs. With Better Maintenance It Can Reserves In Smooth And Efficient Operations Of An Industry Which Helps In Maintenance In Deeds In Improving Productivity .Which Helps In Maintenance Of Machine With Maximum Efficiency Of Economy. For Improvement Of Reliability Many New Control System Technologies Are Utilized.

2. Data Collection

The Data Is Collected From The Reputed Mine. The Mining Parameters Of Dragline And Dragline Parameters Will Show In Table 1, Table 2 And Table 3.

Table 1 Productivity Factors

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 (N_s)	3
No Of Days In A Year (N_d)	365
No Of Hours In A Day (N_h)	8

Table 2 Parameters Of Dragline

Parameters	**Details**
Dragline [Bucket (M^3)/Boom (M)]	24/96
Operating Radius (M)	88
Cutting Width (M)	60
Bench Height (M)	30-35
High Slope Angle (Degrees)	70
Bench Slope (Degrees)	60
Angle Of Repose (Degrees)	38
Digging Depth (M)	25
Method Of Working	Extended Bench Method
Thickness Of Coal Seam (M)	4.5
Over Burden Dump Height (M)	42

Table 3 Mining Parameters Of An Opencast Mine

Parameters	**Details**
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

II. Methodology

The Dragline Performance and Maintenance Data Is Collected From The Reputed Mine. This Data Will Give The Annual Output Of Dragline Based On The Data. The Ownership And Operating Cost Is Also Calculated.

3.1 Availability (A) And Utilization (U):

To Calculate the Availability And Utilization Factor [5] Of The Dragline By Submitting The Field Data In The Below Equations (I) And (Ii),

$$\textbf{Availability (A)} = \frac{\mathbf{SSH}-(\mathbf{MH}+\mathbf{BH})}{\mathbf{SSH}} \qquad \textbf{…….. (I)}$$

$$\textbf{Utilization (U)} = \frac{\mathbf{SSH}-(\mathbf{MH}+\mathbf{BH}+\mathbf{IH})}{\mathbf{SSH}} \qquad \textbf{…….. (Ii)}$$

Where,
SSH Is A Scheduled Shift Hour,
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 (P) Of The Dragline Has Been Projected Using Equation (Iii),

P= (B/C)*A*U*S*F*M*Ns*Nh*Nd*3600 ……..(Iii)

Where
A Is Availability,
U Is Utilization Factor,
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,
Ns Is the Number of Operating Shifts in a Day,
Nh Is The Number Of Operating Hours In A Shift
Nd Is the Number of Operating Days in a Year,

3.2 The Maximum Depth Of The Dragline :

The Maximum Depth Can Be Work Done By Dragline H,

$$\mathbf{H=}\ \frac{\mathbf{T+\tan x\left(R-\frac{W}{4}\right)}}{\mathbf{S+\frac{\tan x}{\tan y}}} \qquad \text{…… (Iv)}$$

Where,
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.

3.3 Amount Of Rehandle (P_{RM}):

$$\mathbf{P_{RM}=}\ \frac{\mathbf{1.125T+0.684H+0.1R}}{\mathbf{W}}+\frac{\mathbf{0.25t2-0.4T-0.16R2}}{\mathbf{HW}}+\frac{\mathbf{0.1T+0.08R-0.01W}}{\mathbf{H}}\text{…… (V)}$$

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. Calculations

By Using The Field Data And Recommended Values In Equations (I), (Ii), (Iii), (Iv) And (V) Then Following Result Is Obtained,

a. The Projected Annual Output Of The Dragline Is 2.87 M M^3 ,
b. The Maximum Depth That Can Be Worked Is 29.74 M,
c. The Amount Of Rehandle Percentage Is 40.2%.

4.1 Calculation of Ownership Cost Of Dragline

a. Cost Of The Equipment Rs 100 Crore.
b. Depreciation Cost For 30 Year I.E. Yearly Flat Rate Of 5% Yearly Depreciation Cost Of 24/96 Dragline = Rs.5 Crore.
c. Average Investment Cost == $\frac{\mathbf{N+1}}{\mathbf{2N}}$*** Cost Of Dragline,** N Is Life Of The Dragline 30 Years. Average Yearly Investment
= Rs. $\frac{100*31}{2*30}$ =Rs 51.66crore.
d. Yearly Interest, Insurance Rates And Taxes I.E. Yearly Flat Rate Of 12.5% =12.5 % Of Rs. 51.66crore = Rs. 6.45crore,
Hence The Total Owner Ship Cost Per Year = Annual Cost + Annual Interest .Hence The Total Owner Ship Cost Per Year
= 5+6.45 = Rs 11.45crore.

4.2 Operating Cost Per Year

a. Yearly Manpower Cost (Salary And Wages) Operator Cost @ Rs. 2 Lakhs/Operator For 2 Operators In Shifts=Rs.12L,
Helper Cost @ Rs. 1.4 Lakh And For 1Operator In 3 Shifts =Rs. 4.2 Lakhs, Total Manpower Cost = Rs0.162 Crore.

b. Power And Energy Consumption On The Basis Of 13.65MKWH For 24/96 Yearly Power Consumption Cost @ Rs 4.89/KWH
$= 4.89*13.65*10^6$ =Rs.6.675 Crore.

c. Yearly Lubrication Cost @ 30% Of Power Consumption = Rs. 2 Crore.

d. Yearly Maintenance Cost @ 20% Of Depreciation Cost = Rs.1 Crore.

e. Major Breakdown Cost @ 2% Of Cost Of Equipment = Rs. 2 Crore.
Hence, Total Yearly Operating Cost = Manpower Cost/Year +Electrical Cost/Year+ Maintenance Cost/Year + Lubrication Cost/Year = Rs. (0.162 + 6.67 + 2 +1+2) Crore = Rs. 11.837 Crore
Total Owner Ship Cost = Ownership Cost/Year + Operating Cost = Rs. (11.8+11.45) Crore = Rs. 23.25 Crore.

4.3 Calculation Of Cost Per Ton Of Coal Exposed Of Dragline By Extended Bench Method

a. Dragline Deployed Is 24/96 Having A Production Capacity Of 2.87 M M^3/Year Percentage Rehandling Is 40.2%,

b. 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 = 2.04 M M^3,
Amount Of Coal Exposure = (2.04 M M^3)/ (2.41m^3/Tonne) = 0.84 M Tonne
Estimated Cost Per Tonne Of Coal Exposed = Rs. $(23.25*10^7)$/ $(0.84*10^6)$ = Rs. 276.67 Tonne Of Coal Exposed.

IV. Result

By SSH, WH, BH, IH And MH The Results Are Obtained From Above Calculations Cost Per Tonne Of Coal Exposed Is Rs. 276.67.Annual Output Of The Dragline Is Rs 2.87m^3 Annual Ownership Cost Is Rs. 11.8 Crore And Annual Operating Cost Is Rs. 11.45 Crore. Dragline Is Best Suitable Machinery In Order To Achieve Huge Production, Remove Huge Volumes Of Overburden With In Shortest Available Time. Availability And Utilization Plays A Crucial Role And They Also Considered As A Tool For Making Decision In Opencast Mining Operation.

V. Conclusion

By This Study Its States Calculation Of Annual Output, Maintenance And Operation Cost. With Better Maintenance It Gives Better Productivity, Wear And Tear.

To Improve Performance Of Dragline Following Suggestions May Be Adopted.

a. Employing A Spare Dragline Operator And Reducing The Variability In Dragline Operator Performance.

b. Better Preventive Maintenance Schedule To Reduce The Breakdown Time And Breakdown Costs.

c. For Improving The Performance Of Draglines By Decreasing The Cycle Time, Ideal Time And Upgrade The Maintenance Strategies.

d. Communication System Should Be Modernized.

References

[1] A Critical Investigation Of Digging Time Segment Of Draglines In A Large Surface Mine By Mousa Mohammadi , Piyush Rai , S. Kazem Oraee Geotech Geol Eng (2015) 33:763–771 DOI 10.1007/S10706-015-9857-9.

[2] P. V. Washimkar, V. S. Deshpande, J. P. Modak And Mrs.A. V. Nasery, Formulation Of Preventive Maintenance Schedule For Dragline System, IACSIT International Journal Of Engineering And Technology, Vol.3, No.4, August 2011

[3] Dragline Maintenance Engineering B.E Research Project By Bruce Thomas Jones, 2007

[4] P. Dayawansa, G. Chitty, B. Kerezsi, H. Bartosiewicz And J.W.H. Price, Fracture Mechanics Of Mining Booms, Engineering Failure Analysis Vol. 13, 2006, Pp. 716–725.

[5] Piyush Rai, Performance Assessment Of Draglines In Opencast Mines, Indian Journal Of Engineering & Materials Sciences Vol. 11, December 2004, Pp. 493-498

[6] Crespo Marquez, A, Sanchez Heguedas, A 2002, Models For Maintenance Optimization: A Study For Repairable Systems And Finite Time Periods, Reliability Engineering & System Safety, Mar, Vol.75 Issue 3, P367.

[7] Hartman H L, SME Mining Engineering Hand Book, Colorado Society For Mining And Metallurgy And Exploration Inc1992, 2nd Edition Volume 1.