ANALYSIS OF DRAGLINE PERFORMANCE TO IMPROVE COAL PRODUCTION

Roll No - 21f1003546
Name – Abhishek Prasad Prajapati
Email Id- 21f1003546@student.onlinedegree.iitm.ac.in

- **Executive Summary**

After understanding metadata which contains information on four draglines working hours, maintenance hours, idle hours, breakdown hours, number of buckets of solids and rehandling, Production (in cum), breakdown report, idle report, and cycle time, I inferred the following information to improve the availability of draglines that working hours should be maximized, breakdown and maintenance hours should be minimized.

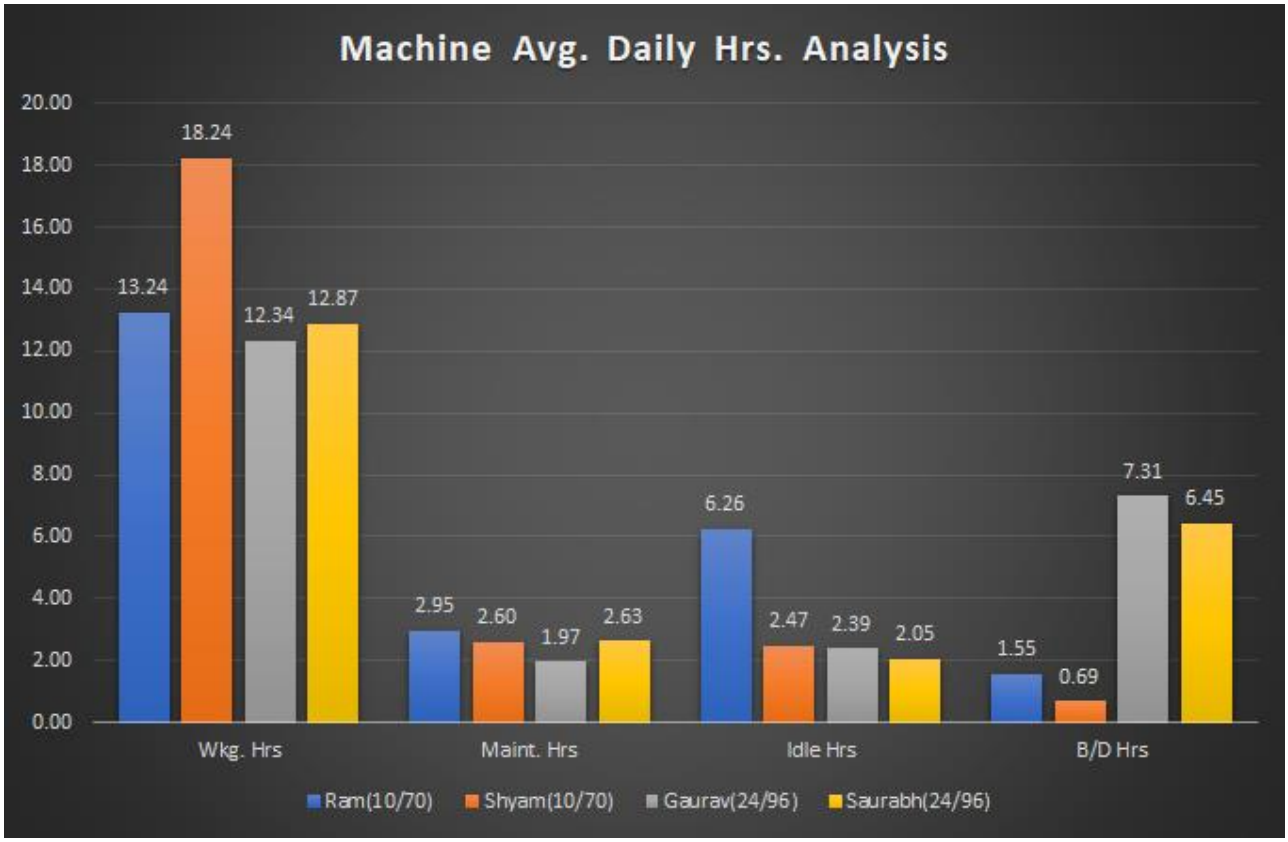
In respect of increasing coal production through draglines, its utilization and capacity utilization must be improved. It can be achieved by increasing working hours and reducing idling hours because, during idle hours, machines are available but still, can't be utilized, and cycle time also affects production since the number of buckets of over burden removed out is inversely proportional to cycle time, reducing cycle time can increase the number of buckets of over burden removed out.

Lastly, for managing the inventory of spare parts conditional report should be used to analyze the failures of the major and minor systems due to which machines are got breakdown. For those systems which requires immediate correction its spare parts should have to be kept in advance.

- **Detailed Explanation of Analysis Process/Method**

Problem 1- Many times, machines are unavailable so tracking which factor mainly affects its unavailability.

Availability of a machine represents the total number of hours for which the machines can be utilized for production if and only if it is free from any event of maintenance or breakdown or in other words, we can say availability represents the period for which machines are available for work.



So, for understanding availability of four draglines in the mine whose names are RAM, SHYAM, GAURAV, and SAURABH, its working hours, idle hours, breakdown hour sand maintenance hours are covered in sheet 1-4 under metadata and all these data are recorded for one month over total shift hours of 24 Hrs. I calculated average working hours (a), average idle hours

(b), average breakdown hours (c), average maintenance hours (d) and average total shift hours (e) = 24hr. Created a summary table for analysis, written dragline names in 1st column, then average working hours (a), average idle hours (b), average breakdown hours (c), average maintenance hours (d) and average total shift hours 24 over further columns

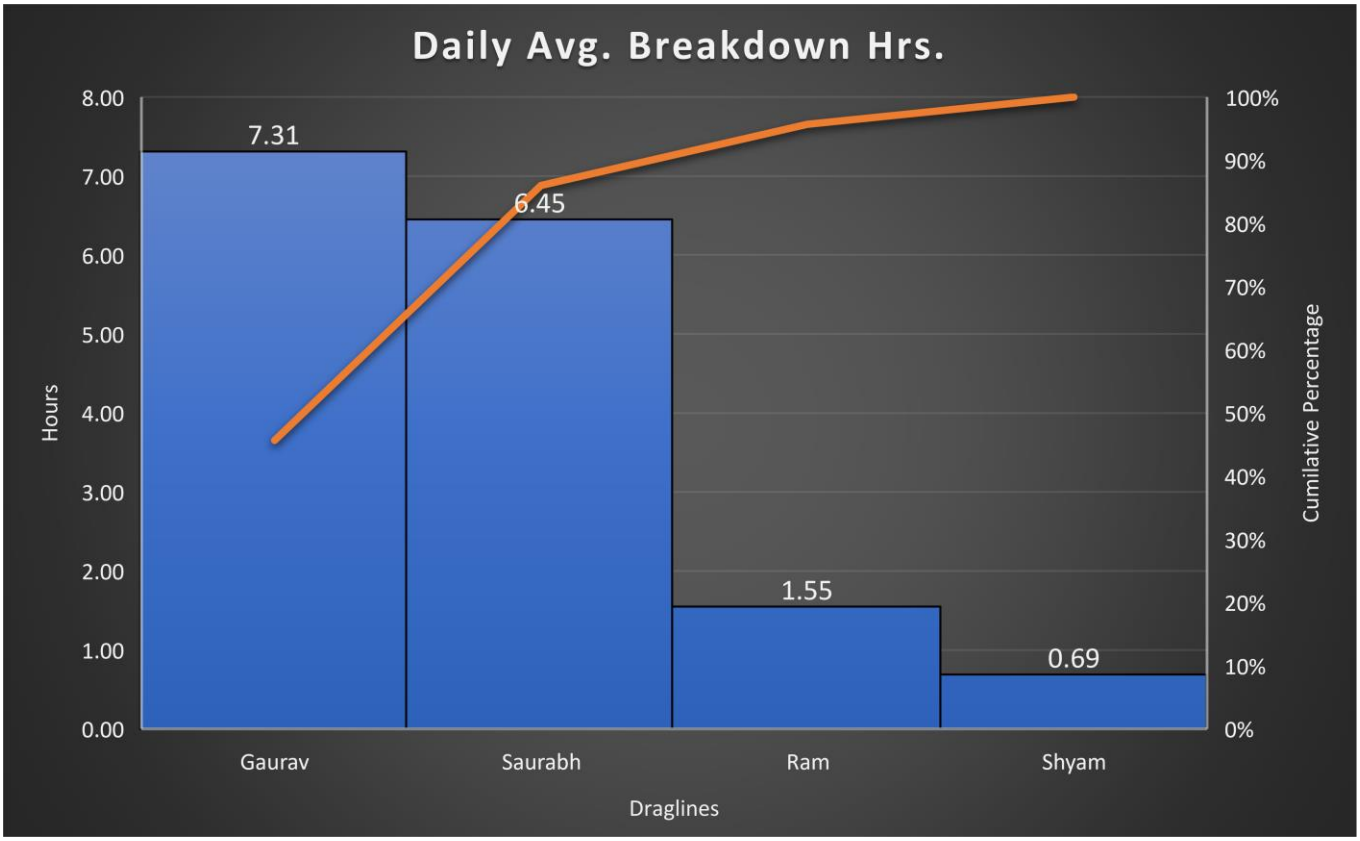
Now, as we know the percentage of availability of machines can calculate by using the formula:

$$\% \text{ availibility} = \frac{\text{Total shift hours(e) - Breakdown hours (c)-Maintenance hours (d)}}{\text{Total shift hours(e)}} \times 100\ \%$$

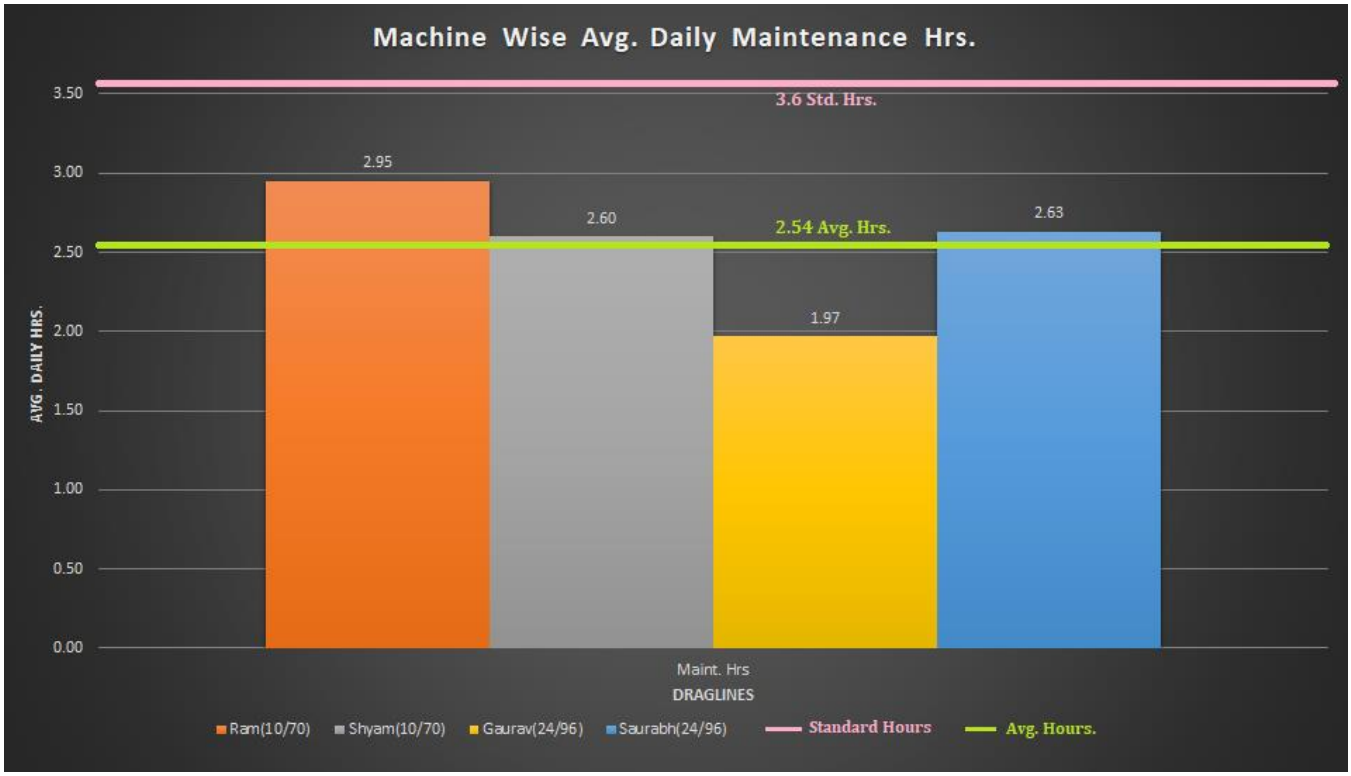
Dragline	Average Hrs. Per day/equipment					Percentage
	Working Hrs. (a)	Idle Hrs. (b)	B/D Hrs.(c)	Maintenance. Hrs.(d)	Total Shift Hrs.(e)	Availability
Ram	13.24	6.26	1.55	2.95	24.00	81.25
Shyam	18.24	2.47	0.69	2.60	24.00	86.29
Gaurav	12.34	2.39	7.31	1.97	24.00	61.35
Saurabh	12.87	2.05	6.45	2.63	24.00	62.17
Average per day	14.17	3.29	4.00	2.54	24.00	72.76
Standard Norm	17.52	2.88	0.00	3.60	24.00	85.00

Table-01

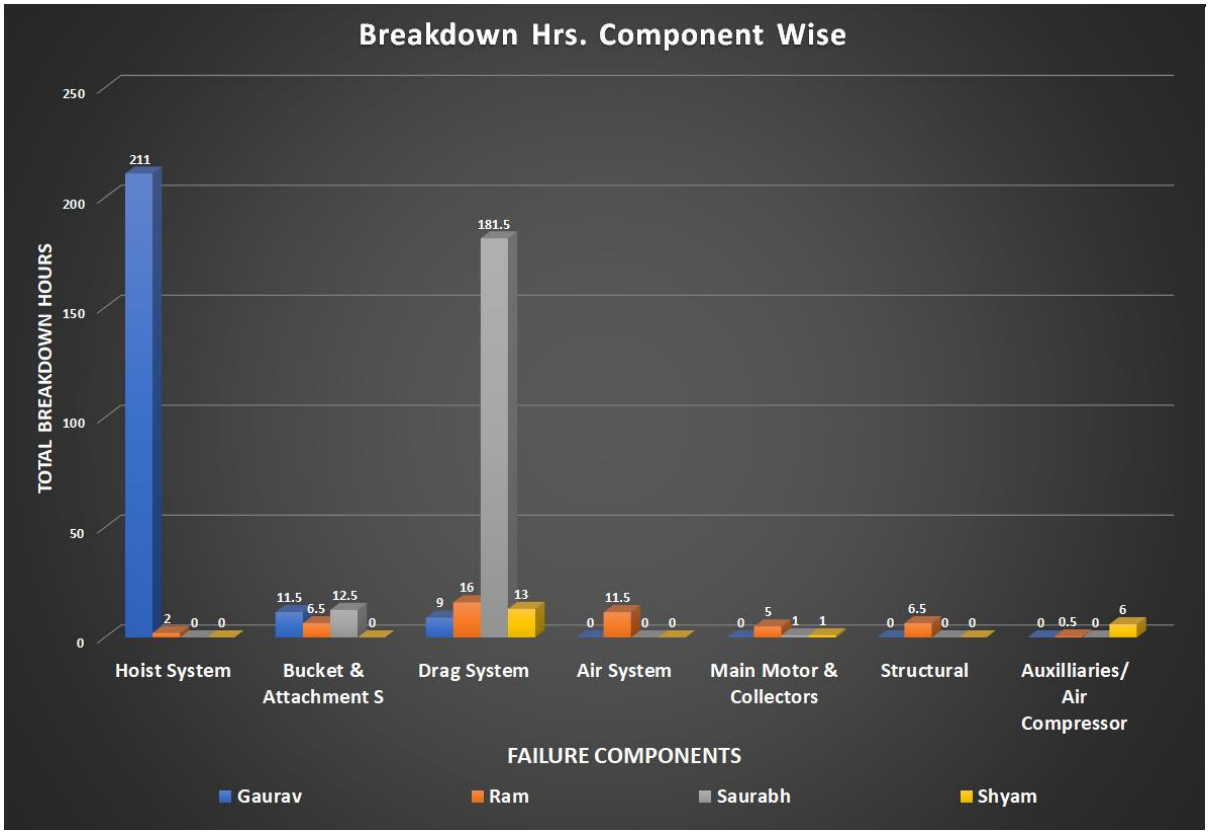
I had compared draglines individually with the standard percentage of availability i.e. 85%. Here we can see that all draglines are underrated over the standard percentage of availability except Shyam. Gaurav and Saurav draglines are lagging too much behind since maintenance hours and breakdown hours are directly proportional to the percentage of availability and total shift hours is constant for all draglines. Hence, we can conclude that reduction of maintenance and breakdown hours can improve the availability of draglines.



Then after I had plotted Pareto Chart for breakdown hours and maintenance hours there, I noticed that for Gaurav and Saurabh draglines breakdown hours are significantly high and if we observe maintenance hours for all draglines.



Then we can notice all have lower maintenance hours than standard maintenance hours, so here breakdown of draglines affects mainly to unavailability. Hence, to minimize the failure of machines I used breakdown report to plot the column bar chart there I found the main reason behind the lagging of Gaurav and Saurabh draglines in respect of unavailability.



Problem 2 - Growth in production, improving machine utilization as well as capacity utilization of draglines.

For increasing growth in coal production through draglines utilization and capacity utilization of machines should be higher. As Utilization signifies the usage hour of machines which contributes to production. In mines, machines may be available but still may not be in working conditions due to inordinate idling conditions hence utilization mainly refers to the loss in available hours.

Utilization of machine can be calculated by using

$$\% \text{ utilization} = \frac{\text{Working hours (a)}}{\text{Total shift hours(e)}} \times 100\ \%$$

From the above table-01, I found working hours and total shift hours for all four draglines are 24 Hrs.

So dividing working hours by total shift hours I got the percentage of utilization of draglines.

As we see from the production sheet in the metadata then Ram and Shyam have a maximum capacity of 10 cum per bucket and Gaurav and Saurabh have a maximum capacity of 24 cum per bucket but as these draglines are aged then Its capacity is around 8 cum for Ram and Shyam and 19 cum for Gaurav and Saurabh So now for calculation purpose, I had used safe capacity instead of maximum capacity. The actual capacity of Ram and Shyam is 5 cum, 17 cum for Gaurav and Saurabh in that period of the month.

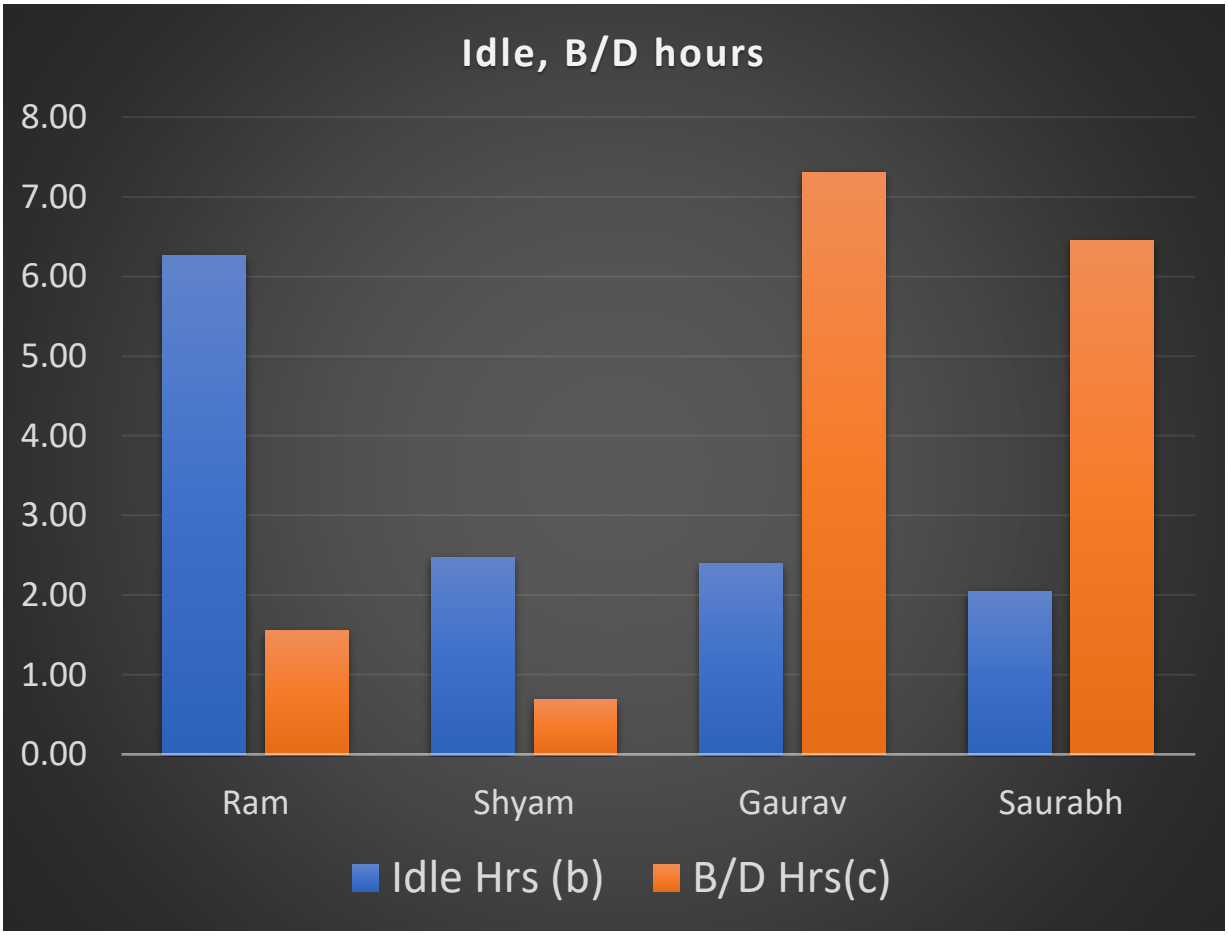
$$\text{Percentage of Capacity Utilization} = \frac{\text{Average Production (in Cum)}}{\text{(Safe) Maximum Production (in Cum)}} \times 100$$

From the production sheet, I calculated the average production of Ram, Shyam, Gaurav and Saurabh draglines by using the excel =AVERAGE() formula and the maximum safe production I calculated by multiplying the total number of buckets by their respective maximum capacity (safe) per bucket, then created a table with dragline names over 1st column, Maximum production(Safe) capacity, Average number of buckets over one month, Average capacity, percentage of utilization, percentage of capacity utilization, percentage of loss due to rehandling over further columns.

Then I plotted a column chart for the percentage of utilization shown below here it's obvious that only Shyam has crossed the standard norm else other draglines are lagging behind.

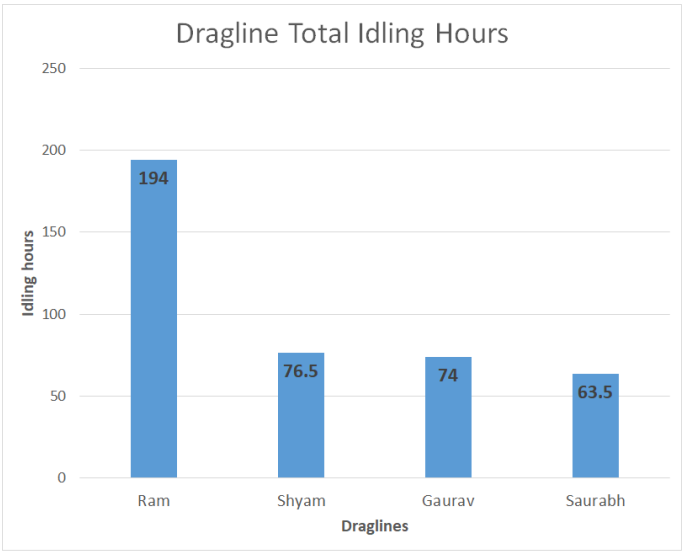
Dragline	Capacity (Safe Capacity)	Production(Max Capacity)/day (in Cum)	Working Hrs. (a)	Avg. Production / Day (nos. of buckets) Solid	R.H.	Production(Safe Capacity) / day (in Cum)	Avg. Production/ Day (in Cum)	% Utilization	% Capacity Utilizn	% loss due to Rehandling
Ram	10 cum/ 70 m (8 cum)	3952	13.24	384	11	3072	1920	55%	63%	3
Shyam	10 cum/ 70 m (8 cum)	5448	18.24	544	1	4359	2719	76%	62%	0
Gaurav	24cum /96 m (19 cum)	8772	12.34	325	40	6944	4557	51%	66%	11
Saurabh	24cum /96 m (19 cum)	9364	12.87	216	174	7413	3026	54%	41%	45
Average per day		6884	14.17	1469	226	5447	3055	59%	56%	13
Standard Norm			17.52					73%	100%	

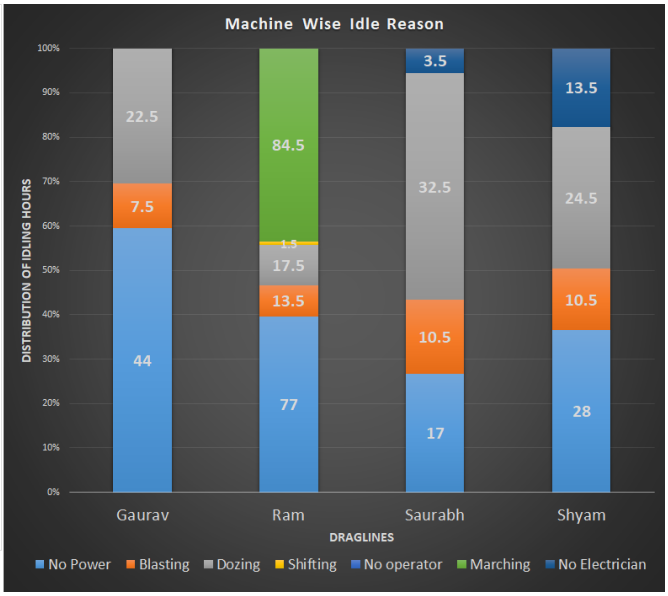
Since Utilization of draglines are affected by mainly idling and breakdown period.



Through this chart which is created by using average idle hours and average breakdown hours across four draglines we can see that utilization of Ram draglines id lagging because of idling hours of Ram is higher and for Gaurav, Saurabh breakdown hours is more.

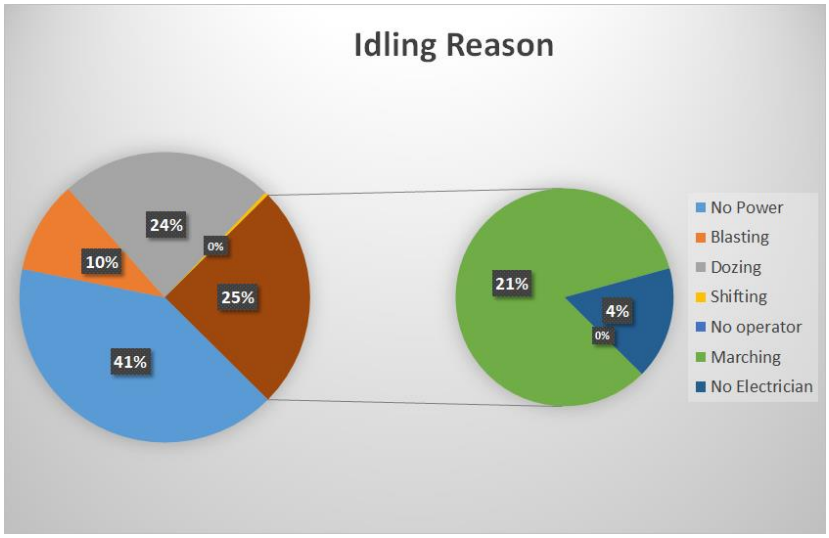
Reason for Gaurav and Saurav breakdown is tracked in previous part so now analyzing reason behind Ram dragline idling condition using idling report under metadata.





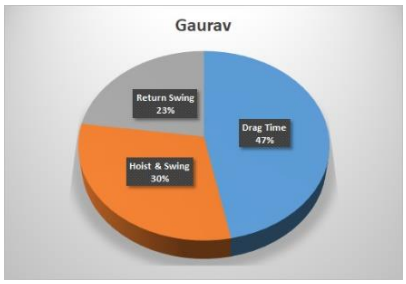
Here it's obvious that **marching** and **no power** is the main cause of Ram's dragline for idling.

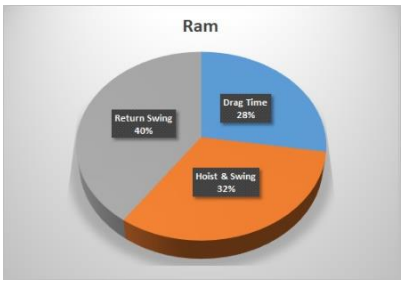
For the analysis of idling alone plotting pie chart along 4 draglines with idling hours data.

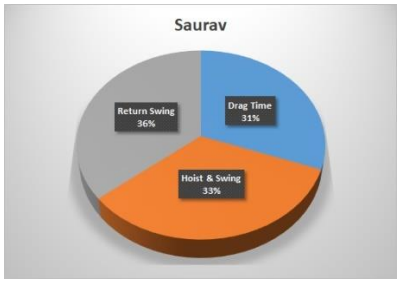


For **cycle time analysis** I used a cycle_time_machine_wise sheet where I calculated the mean of drag, hoist, return swing and total cycle time for Ram Gaurav and Saurabh. By decreasing, cycle time production can be improved since cycle time is directly proportional to the number of buckets then created pie charts.

Cycle time data for Shyam was not available.

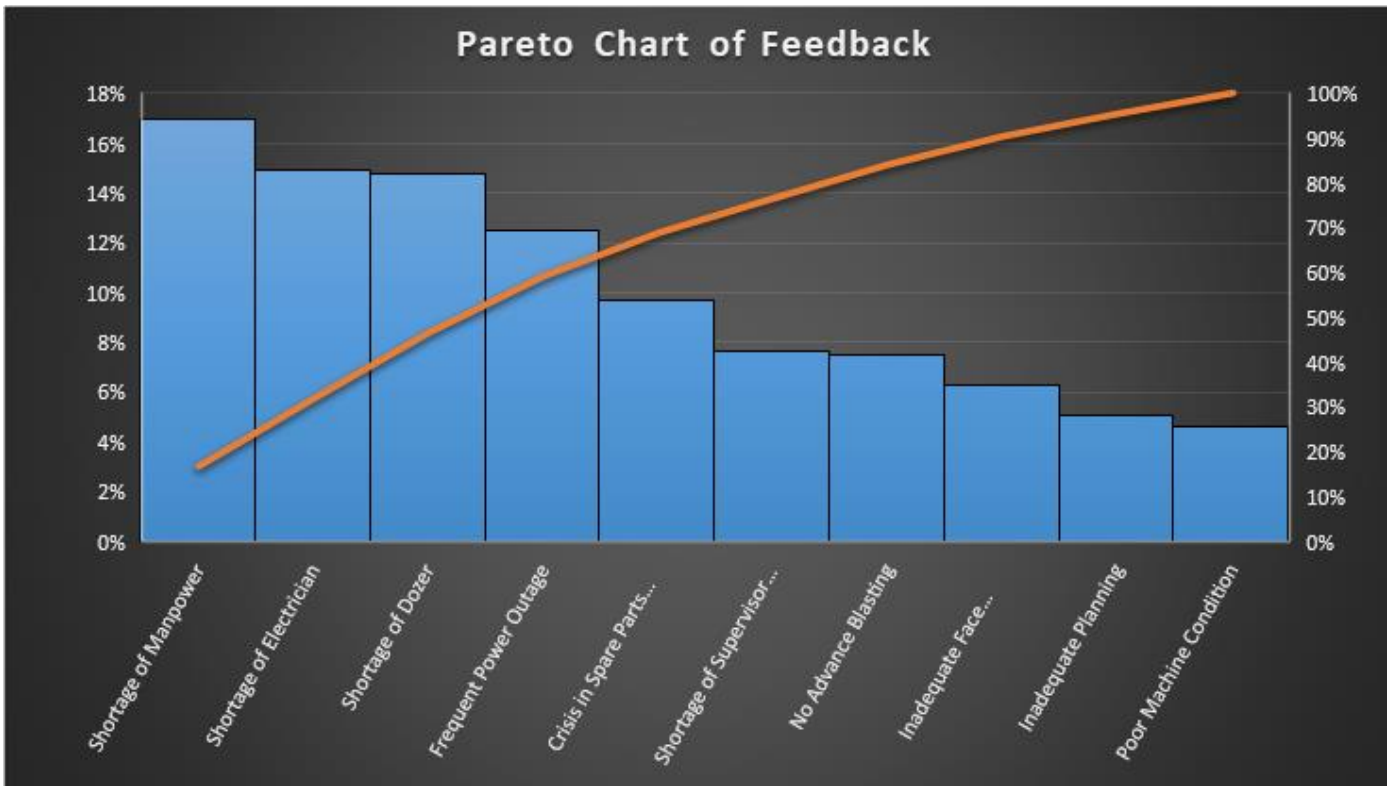






At last feedback, opinion survey was very helpful for understanding the lower capacity utilization of machines. This feedback was rated by various departmental executives along with dragline operators since operators can give accurate descriptions of their machines. It was rated between 1-10 then summed up to calculate the percentage than after I had created a Pareto chart from tabular data.

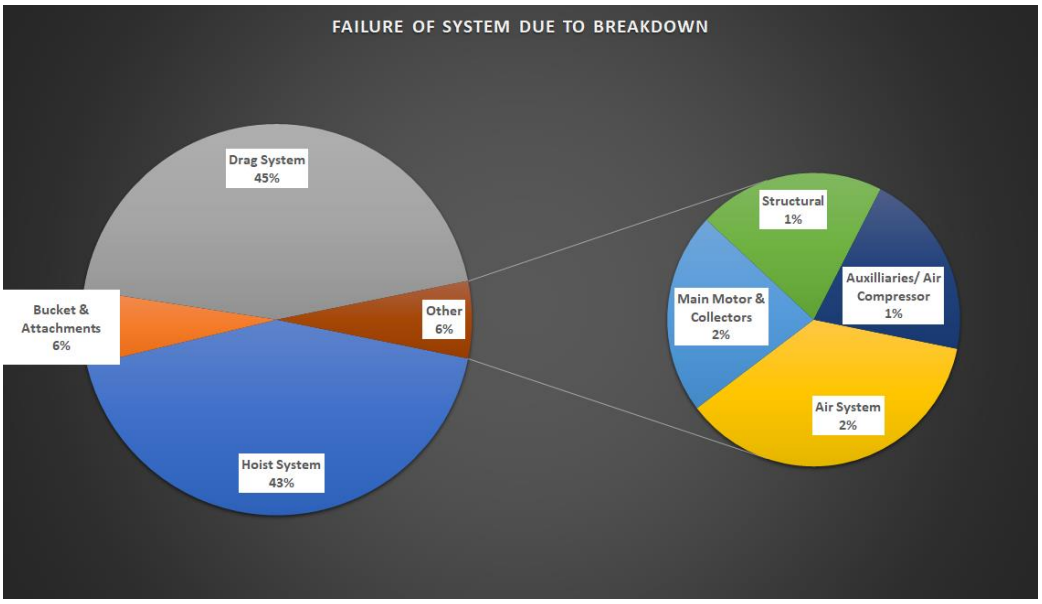
Reasons	Executive(1)	Executive(2)	Operator	Foreman (M)	Overman	EPH	Electrician	Operator	Foreman	Fitter	Operator (2)	Sub- Total	Percentage
Shortage of Manpower	5.00	8.00	0.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	8.00	84.00	17%
Shortage of Electrician	7.00	7.00	9.00	8.00	8.00	4.00	6.00	5.00	7.00	7.00	6.00	74.00	15%
Frequent Power Outage	9.00	9.00	8.00	4.00	4.00	7.00	4.00	2.00	6.00	5.00	4.00	62.00	13%
Inadequate Face available	3.00	3.00	6.00	0.00	3.00	5.00	2.00	4.00	2.00	3.00	0.00	31.00	6%
Inadequate Planning	2.00	2.00	2.00	1.00	2.00	3.00	1.00	7.00	0.00	2.00	3.00	25.00	5%
No Advance Blasting	6.00	6.00	5.00	2.00	1.00	0.00	3.00	0.00	3.00	6.00	5.00	37.00	7%
Poor Machine Condition	0.00	1.00	3.00	3.00	0.00	1.00	8.00	1.00	4.00	1.00	1.00	23.00	5%
Shortage of Dozer	8.00	5.00	4.00	5.00	7.00	8.00	5.00	6.00	8.00	8.00	9.00	73.00	15%
Shortage of Supervisor/ Executives	4.00	4.00	1.00	7.00	5.00	2.00	0.00	8.00	1.00	4.00	2.00	38.00	8%
Crisis in Spare Parts availability	1.00	0.00	7.00	6.00	6.00	6.00	7.00	3.00	5.00	0.00	7.00	48.00	10%



Problem 3- Analysing which system and assemblies of draglines cause breakdown at regular intervals so that corrective actions can be taken within a time scale, which can help in spare parts ordering.

For problem 3, I used conditional monitoring report which is help full in determining maintenance period of different systems. Also breakdown report shows that 90% of the breakdown is due to the Hoist system and drag system so spare parts for these systems should be kept in advance to reduce breakdown hours.

S.No.	System/Assembly	Ram	Shyam	Garam	Saurabh
1	MG. Set				
2	Exciter Set				
3	Drag System				
4	Hoist System				
5	Swing System				
6	Walk System				
7	Structural				
8	Pneumatic				
9	Lubrication				
10	Ventilation				
11	Air Conditioners				
12	Electrical control & Protection				
13	Gauge, Anunciator etc.				
14	Bucket and Accessories				
15	Safety, Protection, lighting, cables etc.				



Results and Findings

Objective

- Finding Availability and its affecting factor
- Spare parts management
- Maximizing production

Ram
(8 Cum)

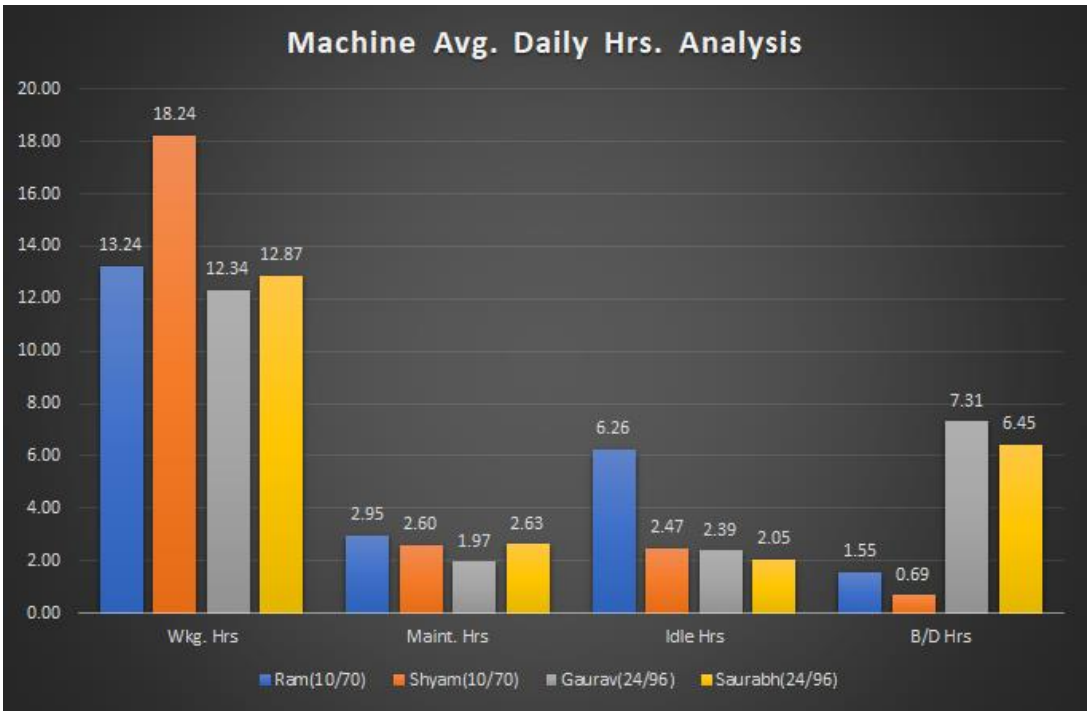
Shyam
(8 Cum)

Gaurav
(19 Cum)

Saurav
(19 Cum)

Finding Availability and factors affecting unavailability

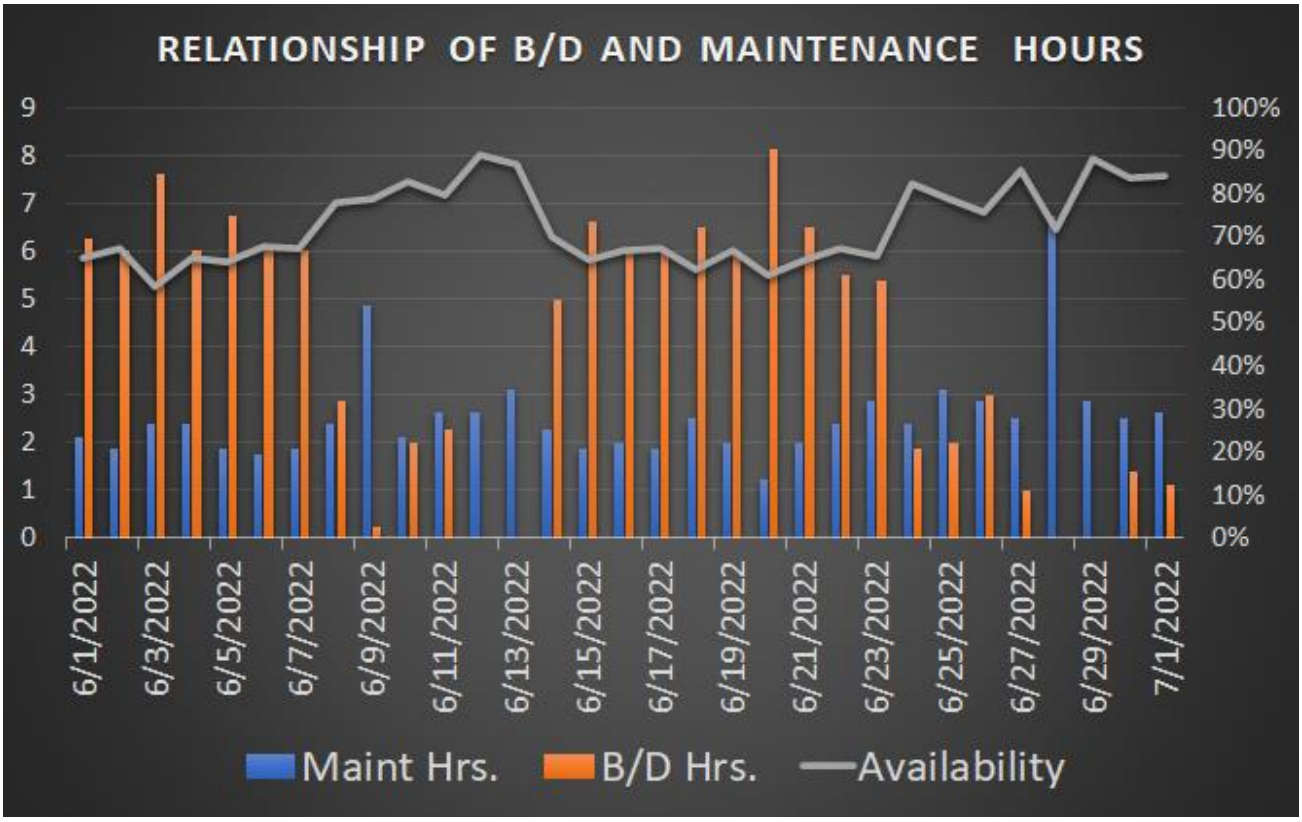
Draglines average daily hours analysis



Percentage of Availability

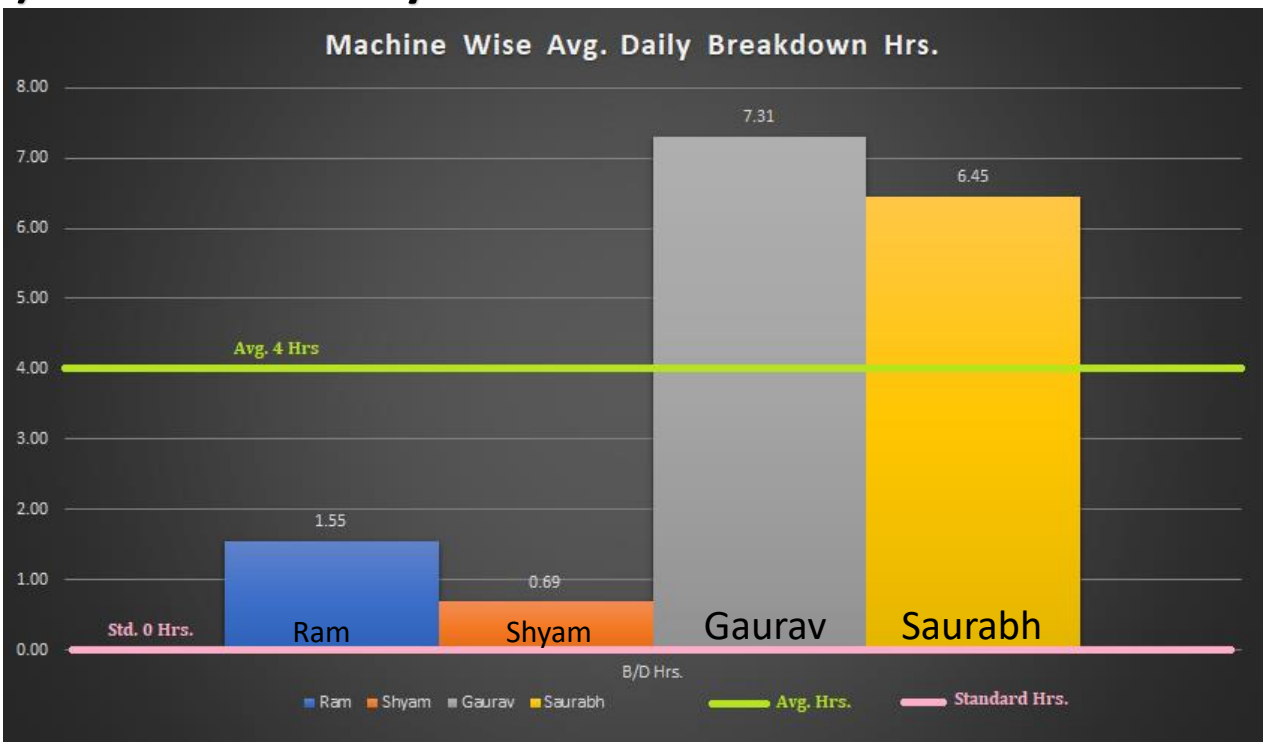
Standard percentage of availability i.e. 85%. Here we can see that all draglines are lagging behind their standard percentage of availability except Shyam.

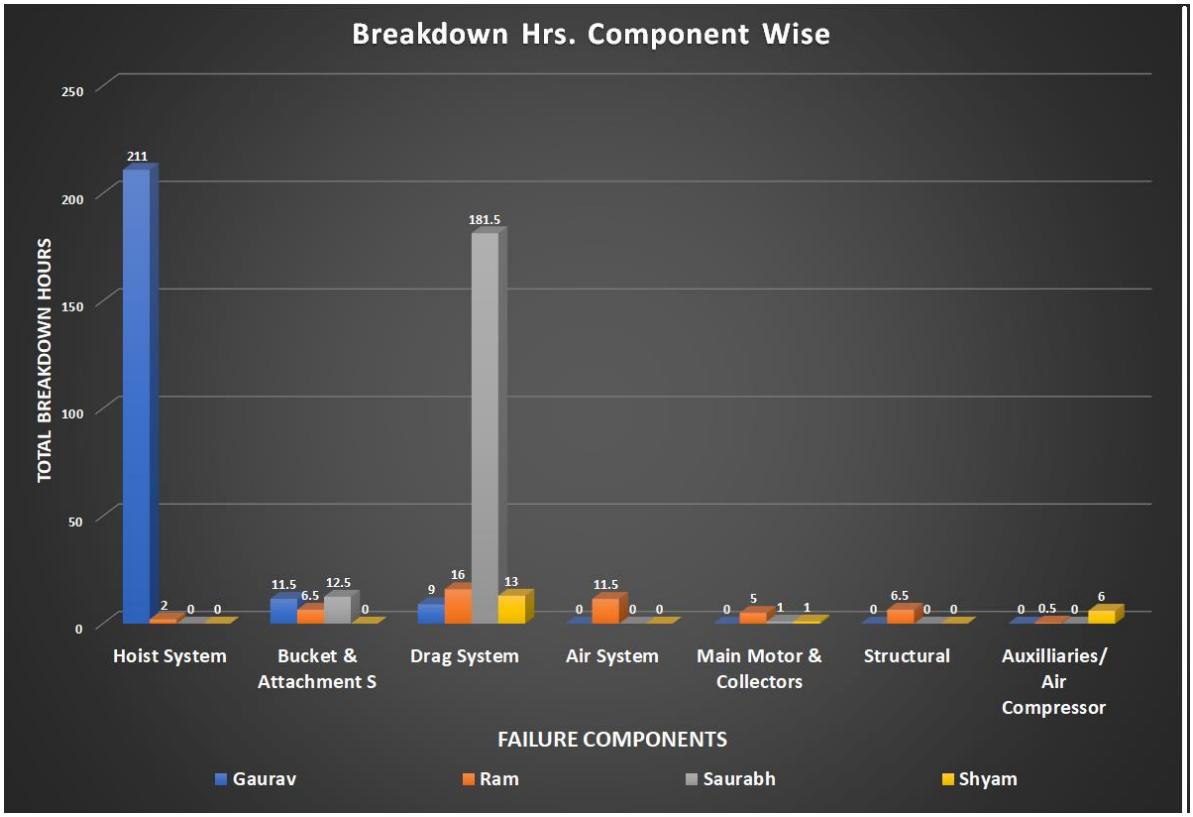
Factors affecting availability



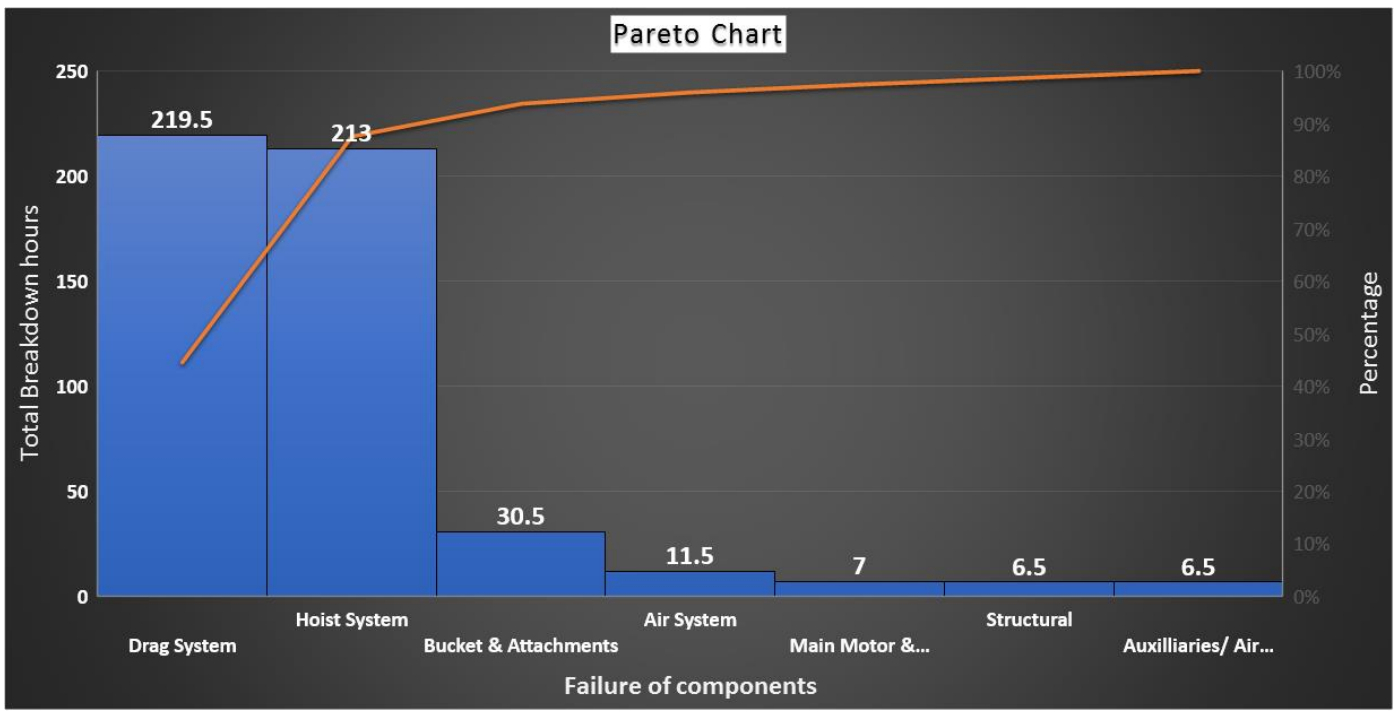
From this graph, we can conclude that percentage of availability is affected by maintenance hours and breakdown hours. Since **Breakdown and Maintenance Hours are opposite to availability** so now analyzing average breakdown hours and average maintenance hours for increment in availability percentage.

1) Breakdown analysis





From the bar chart presented above it can be observed that reason behind higher breakdown hours of Gaurav and Saurabh is Hoist system and Drag system respectively.



It can be inferred from the above graph that the major reason for the breakdown of Draglines is faults in Drag system, hoist system, air system, bucket accessories structural and main motor & ring collectors.

Since major reason behind unavailability is higher breakdown hours so team should work to reduce it.

Conditional Monitoring Report

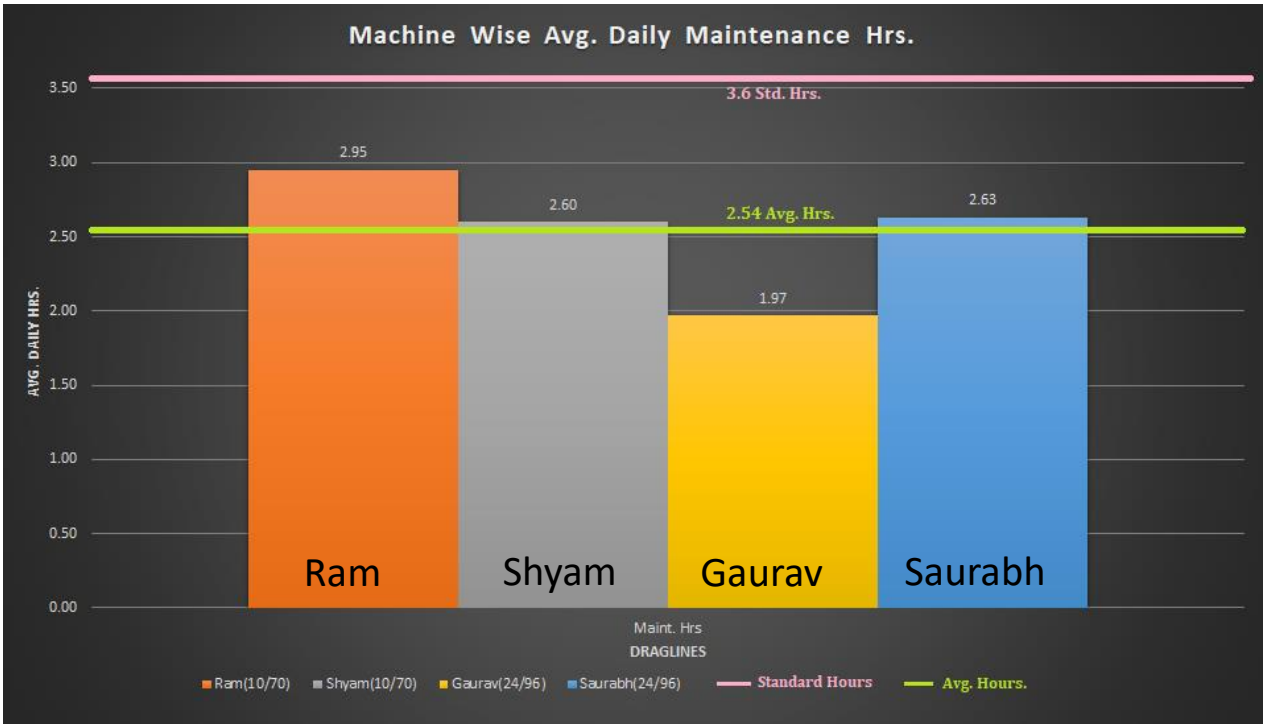
Summary of Condition monitoring report is enclosed which depicts condition of various assemblies and system of draglines and corrective action required to be taken on a time scale, from the report it may be inferred that following dragline wise corrective actions are required which can help in maintenance and spare parts management also:

S.No.	System/Assembly	Ram	Shyam	Garam	Saurabh
1	MG. Set				
2	Exciter Set				
3	Drag System				
4	Hoist System				
5	Swing System				
6	Walk System				
7	Structural				
8	Pneumatic				
9	Lubrication				
10	Ventilation				
11	Air Conditioners				
12	Electrical control & Protection				
13	Gauge, Anunciator etc.				
14	Bucket and Accessories				
15	Safety, Protection, lighting, cables etc.				

	OK
	Corrective action within week
	Corrective action in a convenient time
	Corrective action within month
	Immediate corrective action

a. Gaurav dragline: Drag system. Hoist system, Swing system. Walk system and Structural faults need immediate corrective action.
b. Saurabh dragline: Drag system, Hoist system. Electrical controls & protection and Structural faults require immediate corrective action.
c. Ram dragline: Exciter set, M G Set, Structural, Safety/ Protection cables require immediate corrective action.
d. Shyam dragline: M G Set, Swing system, and Safety Protection cables require immediate corrective action.

2) Maintenance analysis



Gaurav and Saurabh draglines have significantly high breakdown hours and if we observe maintenance then all have lower maintenance hours than standard maintenance hours, so here breakdown of draglines affects mainly to unavailability.

Spare parts management

Conditional report can help in spare parts management

1 - Ram

S.No.	System/Assembly	Ram
1	MG. Set	
2	Exciter Set	
3	Drag System	
4	Hoist System	
5	Swing System	
6	Walk System	
7	Structural	
8	Pneumatic	
9	Lubrication	
10	Ventilation	
11	Air Conditioners	
12	Electrical control & Protection	
13	Gauge, Anunciator etc.	
14	Bucket and Accessories	
15	Safety, Protection, lighting, cables etc.	

	OK
	Corrective action within week
	Corrective action in a convenient time
	Corrective action within month
	Immediate corrective action

From the above conditional report motor gear set, exciter set, structural set, protection, lighting, cables require immediate corrective action so its spare parts should have to be there while drag system, hoist system, lubrication, swing system, bucket accessories and walk system can be corrected within week/month so its spare parts can be ordered if not there at that moment.

2 - Saurabh

S.No.	System/Assembly	Saurabh
1	MG. Set	
2	Exciter Set	
3	Drag System	
4	Hoist System	
5	Swing System	
6	Walk System	
7	Structural	
8	Pneumatic	
9	Lubrication	
10	Ventilation	
11	Air Conditioners	
12	Electrical control & Protection	
13	Gauge, Anunciator etc.	
14	Bucket and Accessories	
15	Safety, Protection, lighting, cables etc.	

	OK
	Corrective action within week
	Corrective action in a convenient time
	Corrective action within month
	Immediate corrective action

From Drag system, hoist system and electrical control & protection requires immediate corrective action so its spare parts should have to be there while exciter set, , swing system, walk system lubrication, ventilation, Air conditioners can be corrected within week so its spare parts can be arranged within week.

3 - Shyam

S.No.	System/Assembly	Shyam
1	MG. Set	
2	Exciter Set	
3	Drag System	
4	Hoist System	
5	Swing System	
6	Walk System	
7	Structural	
8	Pneumatic	
9	Lubrication	
10	Ventilation	
11	Air Conditioners	
12	Electrical control & Protection	
13	Gauge, Anunciator etc.	
14	Bucket and Accessories	
15	Safety, Protection, lighting, cables etc.	

	OK
	Corrective action within week
	Corrective action in a convenient time
	Corrective action within month
	Immediate corrective action

From the above conditional report motor gear set, swing system, safety protection, lighting, cables require immediate corrective action so its spare parts should have to be there while drag system, hoist system, lubrication, bucket accessories, structural system and walk system can be corrected within week/month so its spare parts can be ordered if not there at that moment.

4 - Gaurav

S.No.	System/Assembly	Gaurav
1	MG. Set	
2	Exciter Set	
3	Drag System	
4	Hoist System	
5	Swing System	
6	Walk System	
7	Structural	
8	Pneumatic	
9	Lubrication	
10	Ventilation	
11	Air Conditioners	
12	Electrical control & Protection	
13	Gauge, Anunciator etc.	
14	Bucket and Accessories	
15	Safety, Protection, lighting, cables etc.	

	OK
	Corrective action within week
	Corrective action in a convenient time
	Corrective action within month
	Immediate corrective action

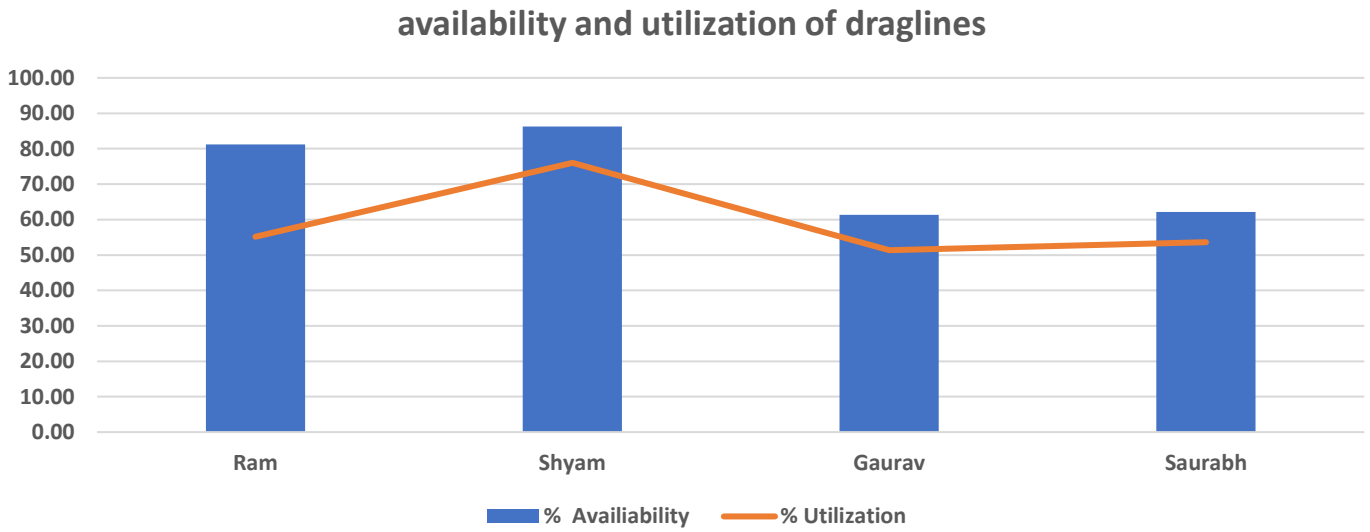
From Drag system, hoist system, swing system, walk system and structural system require immediate corrective action so its spare parts should have to be there while motor gear, exciter set, lubrication, ventilation, electrical control & protection, gauge, annunciator, safety, lighting and cables can be corrected within week so its spare parts can be arranged within week.

Production Maximization

Factors affecting Production

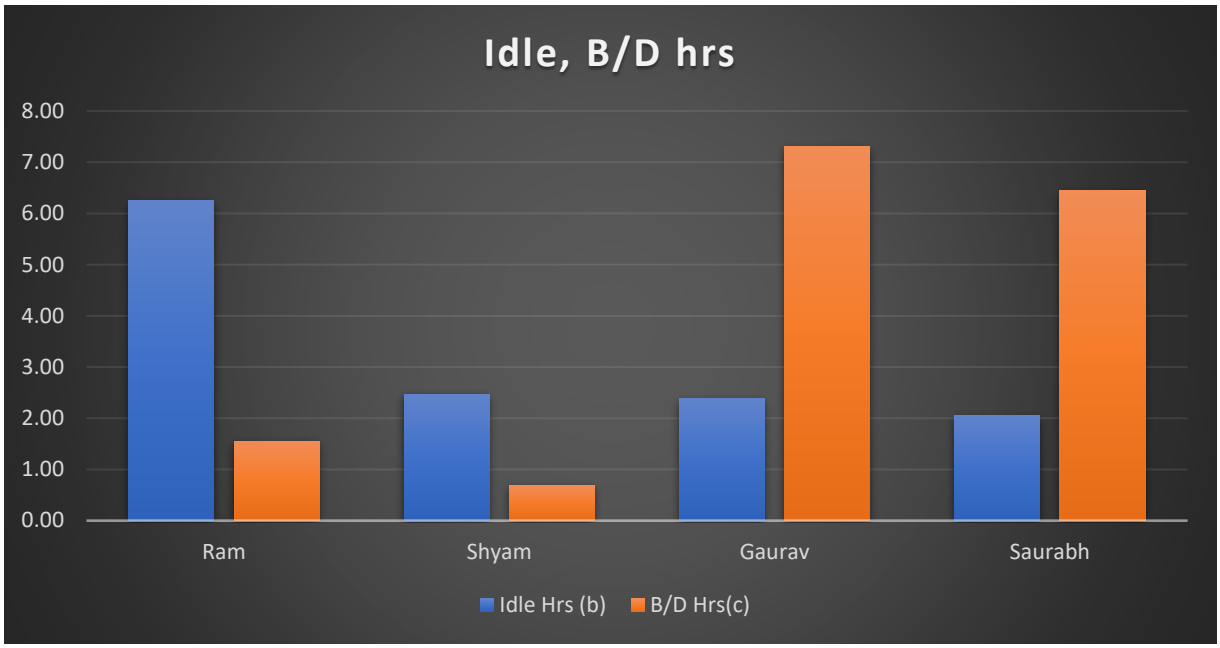
1) Utilization and Capacity utilization of draglines
2) Cycle time

1) Utilization and Capacity utilization of draglines



All draglines are mostly available but they are not being utilized so analysing factors which are affecting draglines lower utilization.

Since utilization of draglines are affected by mainly idling and breakdown period.



This bar chart shows that for idling is reason for ram's dragline and breakdown is the main reason behind Gaurav and Saurabh dragline's lower utilization. Analysis on Breakdown I had done above now analysing idling of draglines.

Reason behind idling of draglines

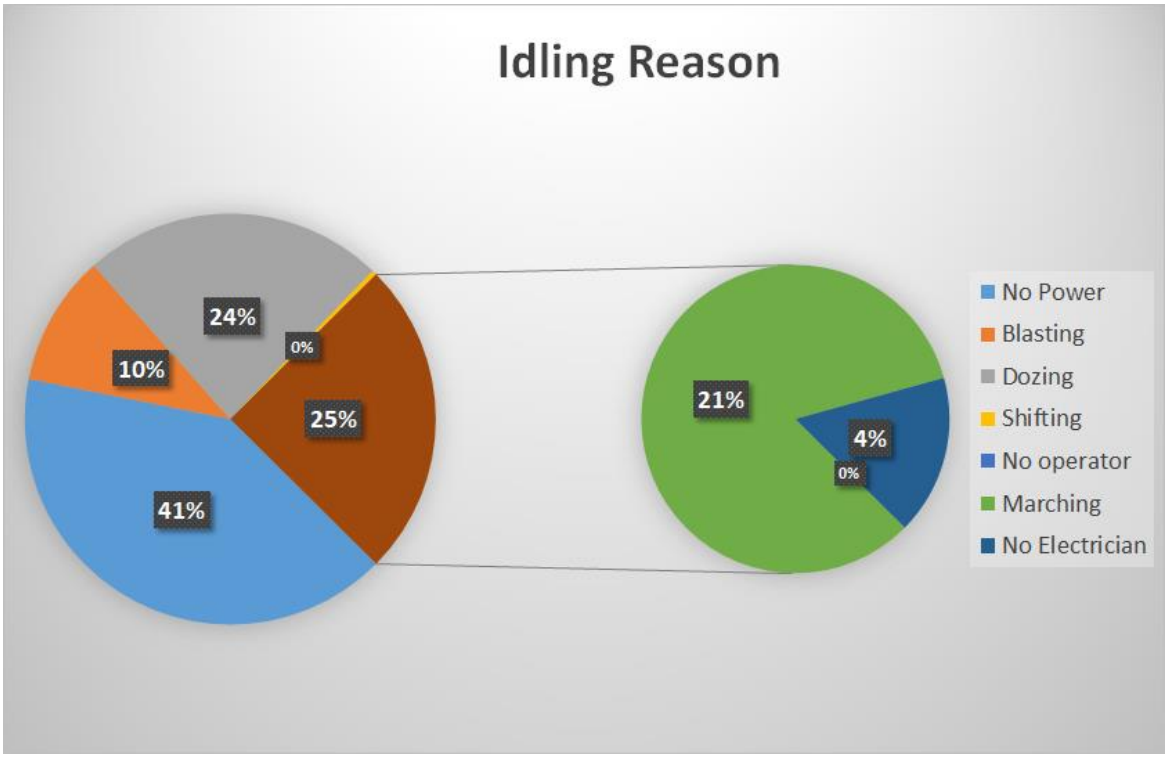
No power, No advance blasting and No pre dozing are reason for Gaurav's dragline idling.

Marching, No dozing, No advance blasting and No pre dozing are reason for Ram's dragline idling.

No power, No advance blasting and No pre dozing are reason for Saurabh's dragline idling.

No power, No advance blasting, No pre dozing and no electrician are reason for Shyam's dragline idling.

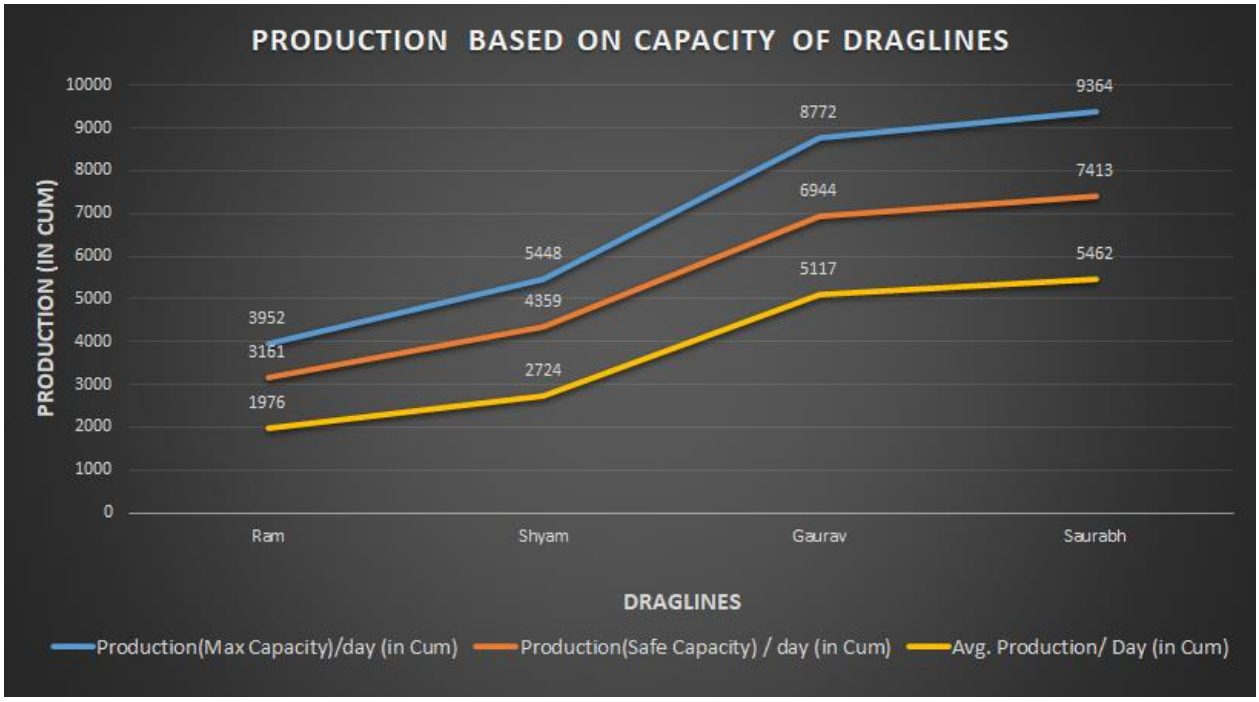
If we look up for combined scenario then No power, dozing, blasting and marching are main factors which affects idling of these draglines.



Capacity Utilization of Draglines

Dragline	Capacity (Safe Capacity)	% Utilization	% Capacity Utilizn	% loss due to Rehandling
Ram	10 cum/ 70 m (8 cum)	55%	63%	3
Shyam	10 cum/ 70 m (8 cum)	76%	62%	0
Gaurav	24cum /96 m (19 cum)	51%	66%	11
Saurabh	24cum /96 m (19 cum)	54%	41%	45
Average per day		59%	56%	13
Standard Norm		73%	100%	

All draglines have low capacity utilization percentage specially for Saurabh dragline who was doing rehandling.

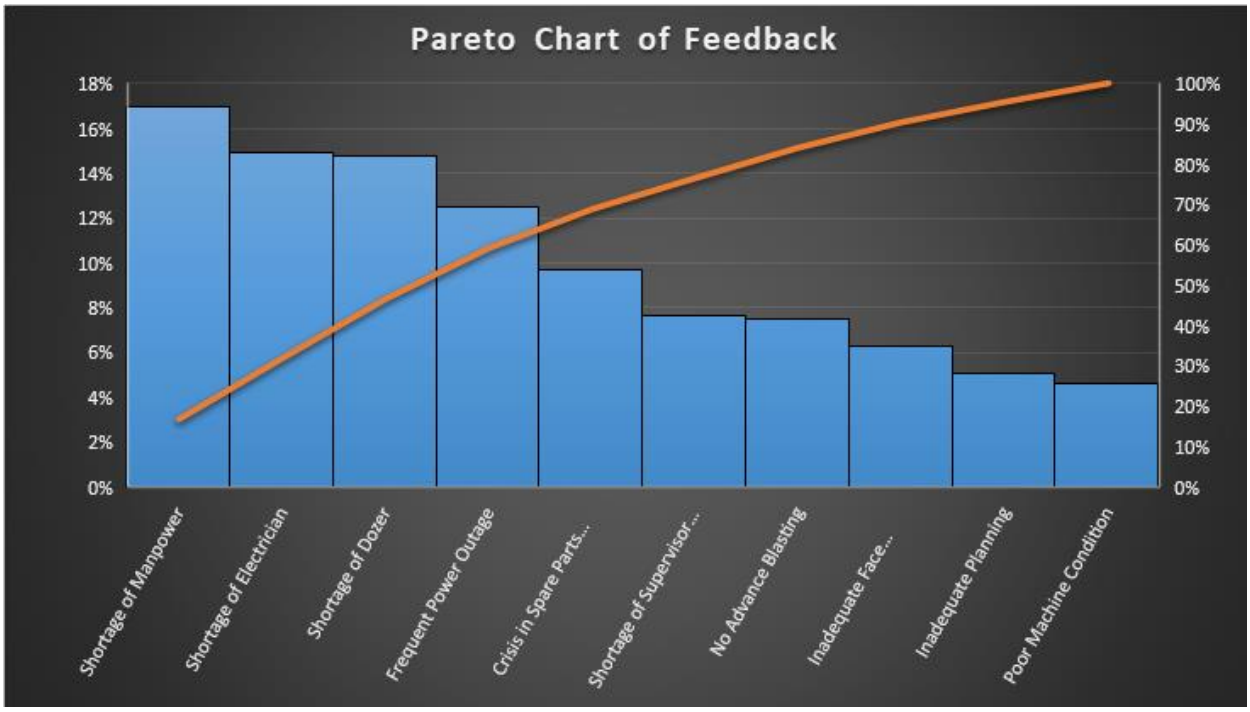


From above line graph its clear that all draglines are lagging behind in terms of coal production

Now analysing feedback form for lower capacity utilization through draglines

In order to find out the major constraints in performance of Draglines in the coal lines, a feedback survey was done which was filled by the manpower engaged in operation and maintenance of the draglines. Analysis on this feedback in on next page.

Reasons	Executive(1)	Executive(2)	Operator	Foreman (M)	Overman	EPH	Electrician	Operator	Foreman	Fitter	Operator (2)	Sub- Total	Percentage
Shortage of Manpower	5.00	8.00	0.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	8.00	84.00	17%
Shortage of Electrician	7.00	7.00	9.00	8.00	8.00	4.00	6.00	5.00	7.00	7.00	6.00	74.00	15%
Frequent Power Outage	9.00	9.00	8.00	4.00	4.00	7.00	4.00	2.00	6.00	5.00	4.00	62.00	13%
Inadequate Face available	3.00	3.00	6.00	0.00	3.00	5.00	2.00	4.00	2.00	3.00	0.00	31.00	6%
Inadequate Planning	2.00	2.00	2.00	1.00	2.00	3.00	1.00	7.00	0.00	2.00	3.00	25.00	5%
No Advance Blasting	6.00	6.00	5.00	2.00	1.00	0.00	3.00	0.00	3.00	6.00	5.00	37.00	7%
Poor Machine Condition	0.00	1.00	3.00	3.00	0.00	1.00	8.00	1.00	4.00	1.00	1.00	23.00	5%
Shortage of Dozer	8.00	5.00	4.00	5.00	7.00	8.00	5.00	6.00	8.00	8.00	9.00	73.00	15%
Shortage of Supervisor/ Executives	4.00	4.00	1.00	7.00	5.00	2.00	0.00	8.00	1.00	4.00	2.00	38.00	8%
Crisis in Spare Parts availability	1.00	0.00	7.00	6.00	6.00	6.00	7.00	3.00	5.00	0.00	7.00	48.00	10%

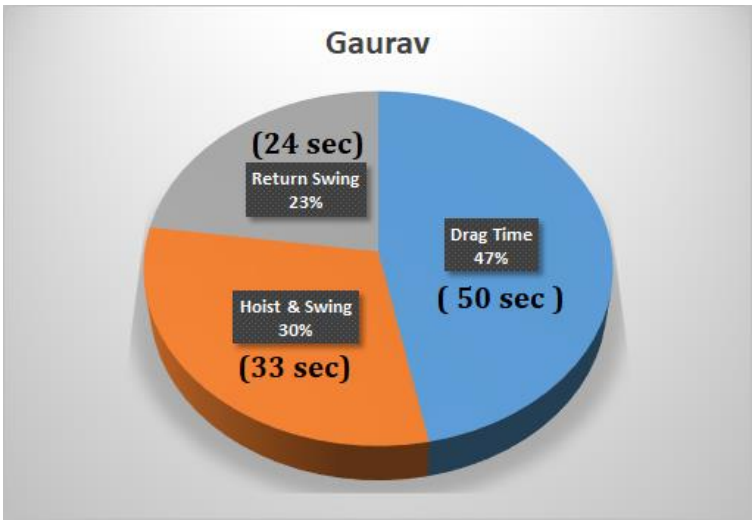


Through feedback analysis we can see shortage of manpower (17%), shortage of electrician (15%), shortage of dozer (15%), frequent power outage (13%), crisis in spare parts (10%) are main reason which are impacting performance of draglines.

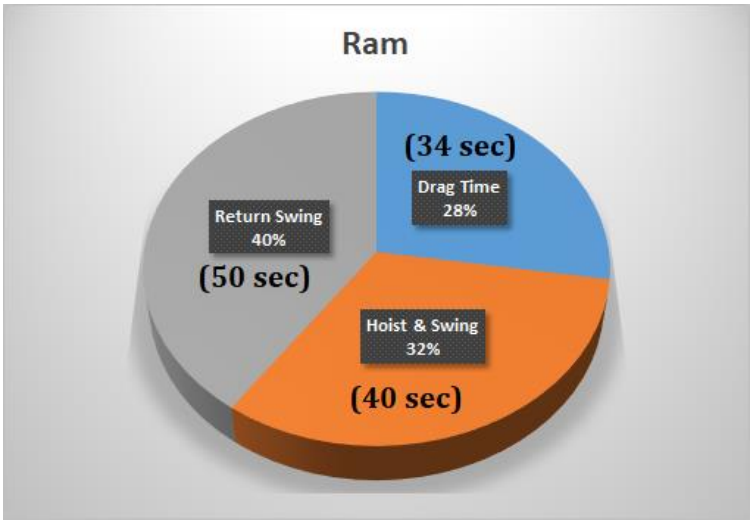
2) Cycle Time

Time taken be machine to complete one cycle from loading till unloading is called Cycle time. By decrease in cycle time we can increase production(increase in number of buckets).

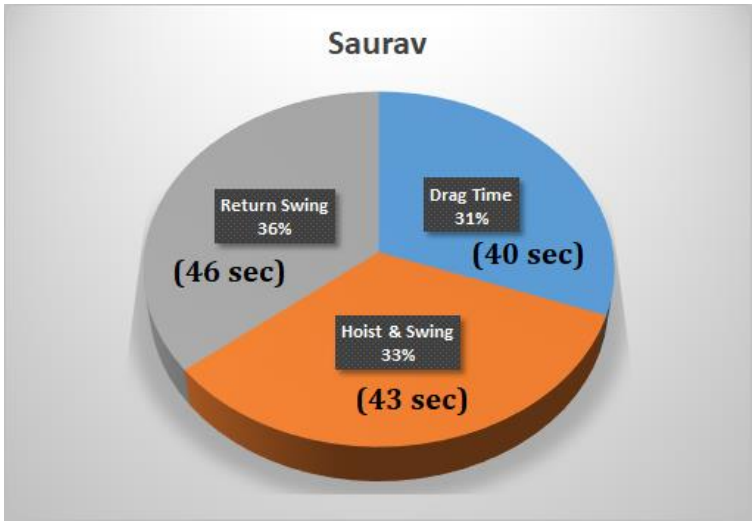
Here available data is for just 3 draglines, Ram, Shyam and Gaurav Draglines. Ram cycle time was recorded for 25 buckets, Shyam cycle time was recorded for 20 cycles and lastly Gaurav cycle time was recorded for 10 buckets.



For Gaurav dragline drag time is 50 seconds which is more than the idle drag time of 14-15 seconds. Due to non-availability of Dozer, the operator of Gaurav Dragline was forced to perform dozing operation by the bucket itself which leads to increase in the overall drag time.



The above chart depicts that the drag time of Ram Dragline is 34 seconds which is more than the ideal drag time of 14 -15 seconds. Ram Dragline was doing upper cut which leads to higher drag time. Further, the Hoist and swing operations were slower.



The above chart depicts that the drag time of Saurabh Dragline is 40 seconds which is more than the ideal drag time of 14 -15 seconds. Saurabh Dragline was deployed in No Coal area and it was doing upper cut which resulted in higher drag time.

Interpretation of Results and Recommendation

Availability Of draglines can be maximized by fixing Drag and Hoist system since Maintenance hours are tune of less than the standard hours.

Manpower requirement: In order to improve the performance of draglines shortages of manpower must be filled up at the earliest.

Advance Blasting and face condition: Appropriate face preparation with adequate advanced blasting is required to be made available for productive deployment of draglines. Action for advance blasting should be implemented to the tune of high depth so that time losses due to frequent blasting and marching could be minimized, for this proper advance action plan (for at least 30 days) for drilling and blasting should be made and accordingly the plan should be implemented in co-ordination with dragline section.

Separate Feeder Switch for each Dragline: Major reason for idling of Ram, Gaurav and Shyam draglines were No Power condition. It is suggested that separate feeder switch for each dragline must be ensured for smooth operation of Draglines in the mines

Dedicated dozer for Each Dragline: Presently there are only 2 nos. of Dozers deployed the Dragline section. In case of any exigency Dozer has to be marched to respective Dragline which is resulting in Idling of other draglines due to shortage of dozers this pattern can also be seen in idling report.

Spare parts: Spare parts for those system which causes frequent breakdown should be kept in advance.