

CHAPTER-5

CHAPTER 5

RESULTS AND DISCUSSIONS

5.1 Assumptions for data analysis

- 1- The time performance data for those months in which dump trucks were fully breakdown were not considered in the analysis i.e. they are assumed as outliers.
- 2- Capacity performance data has been collected by using questionnaire once by more than 50 persons and the average of all the responses has been assumed as the data for the whole study period.
- 3- Environmental performance data has been collected twice in a year and average of these two has been assumed as the data for the whole year.

5.2 Evaluation of Dump Truck Performance

The methodology for the calculation of performance of dump trucks has been described in the Chapter 3. This study uses data collected from two large surface coal mining projects in India. Both the case study mines are highly mechanized and operates with a large fleet of dump trucks.

This study has used operational data of 40 dump trucks (5 are of 85 T and 30 are of 100 T) operated in NCL projects and 5 dump trucks of 85 T capacity operational in BCCL projects.

The calculation of availability (A), utilization (U), capacity performance (C), environmental performance (E) and OEPI for the dump truck (D-10630), having a commencement date of October, 2014, for the year 2017, 2018 and 2019 has been calculated using the Equations 3.1, 3.4, 3.5, 3.7 and 3.8 and presented in Table 5.1,

Table 5.2 and Table 5.3. Availability and utilization have been calculated by taking the data of the time losses which were maintained by the mine management in the equipment logbooks as well as in their server. Dump truck D-10630 was under breakdown in December, 2018 and May 2019. Repair times were unduly high due to delayed availability of spares. These are reflected in Table 5.1 and Table 5.2.

Capacity performance (C) has been calculated by taking the average capacity loss of 2410 Kg for the whole year (response collected by the questionnaire from the mine personnel such as field managers, mining engineers, transport in-charges, dump truck operators, shovel operators, quality inspectors and other related personnel). The questionnaire was distributed to 100 personnel of varying designations and 75 responses were received. The average value of capacity losses under different heads were computed from these responses and found to be 100 kg due to sticky materials, 500 Kg due to under-loading, 210 Kg through spillage of the coal during transportation, and 1600 Kg due to loading of material other than coal. Adding all these four components of capacity losses gives total capacity losses as 2410 Kg. Considering 2410 Kg capacity loss per trip results, capacity performance of dump trucks equal to 95%.

Environmental performance (E) has been calculated using the Equation 3.8 from the measured CO₂ percentage with the help of UNIPHOS gas detector tube and pump. CO₂ was measured twice in a year during this study period. It was observed that the CO₂ percentage was varying from 9.8% - 10.20% during the year 2017 for the dump truck D-10630. For the calculation of E, the average value of CO₂ is considered as 10% for the whole year of 2017. From the measured values of CO₂ which are shown in the Table 5.1, Table 5.2 and Table 5.3, it is clear that environmental performance decreases with the increase of total operating hours i.e., age of the dump trucks. For the dump truck D-10630, it decreases from 83% in 2017 to 81% in 2018 and from 81% to 78% within the

period 2018 to 2019. Environmental performance depends on the health condition of the engine and varies with the size of the dump truck and its manufacturer.

Table 5.1 Calculation of A, U and OEPI of Dump Truck (D-10630) for the year 2017

Month (2017)	SFT	WRK	MNT	BDN	IDL	A%	U%	CL (Kg)	C	%CO ₂	E	OEPI
Jan.	744	508	17	115	104	0.8226	0.8301	2410	0.95	10	0.83	0.5416
Feb.	672	428	94	28	122	0.8185	0.7782					0.5052
Mar.	744	519	19	104	102	0.8347	0.8357					0.5533
Apr.	720	360	79	133	148	0.7056	0.7087					0.3966
May	744	314	60	245	125	0.5901	0.7153					0.3348
Jun.	720	495	25	169	31	0.7306	0.9411					0.5453
Jul.	744	378	73	186	107	0.6519	0.7794					0.4030
Aug.	744	414	54	139	137	0.7406	0.7514					0.4414
Sep.	720	403	49	116	152	0.7708	0.7261					0.4440
Oct.	744	305	29	308	102	0.5470	0.7494					0.3252
Nov.	720	376	69	77	198	0.7972	0.6551					0.4142
Dec.	744	0	0	744	0	0	0					0

Table 5.2 Calculation of A, U and OEPI of Dump Truck (D-10630) for the year 2018

Month (2018)	SFT	WRK	MNT	BDN	IDL	A%	U%	CL (Kg)	C	%CO ₂	E	OEPI
Jan.	744	290	89	189	176	0.6263	0.6223	2410	0.95	9.67	0.81	0.2990
Feb.	672	298	78	98	198	0.7381	0.6008					0.3401
Mar.	744	329	29	84	302	0.8481	0.5214					0.3392
Apr.	720	360	79	133	148	0.7056	0.7087					0.3835
May	744	0	0	744	0	0	0					0
Jun.	720	410	45	184	81	0.6819	0.8350					0.4368
Jul.	744	410	56	210	68	0.6425	0.8577					0.4227
Aug.	744	379	44	129	192	0.7675	0.6637					0.3907
Sep.	720	404	27	89	200	0.8389	0.6689					0.4304
Oct.	744	365	29	267	83	0.6022	0.8147					0.3763
Nov.	720	329	46	108	237	0.7861	0.5813					0.3505
Dec.	744	428	42	88	186	0.8253	0.6971					0.4412

Table 5.3 Calculation of A, U and OEPI of Dump Truck (D-10630) for the year 2019

Month (2019)	SFT	WRK	MNT	BDN	IDL	A%	U%	CL (Kg)	C	%CO ₂	E	OEPI
Jan.	744	380	35	153	176	0.7473	0.6835	2410	0.95	9.33	0.78	0.3780
Feb.	672	240	35	117	280	0.7738	0.4615					0.2643
Mar.	744	275	33	254	182	0.6142	0.6018					0.2735
Apr.	720	308	42	234	136	0.6167	0.6937					0.3166
May.	744	208	32	341	163	0.4987	0.5606					0.2069
Jun.	720	170	68	178	304	0.6583	0.3586					0.1747
Jul.	744	311	46	98	289	0.8065	0.5183					0.3093
Aug.	744	180	30	360	174	0.4758	0.5085					0.1790
Sep.	720	200	37	293	190	0.5417	0.5128					0.2056
Oct.	744	178	51	344	171	0.4691	0.5100					0.1770
Nov.	720	215	39	272	194	0.5681	0.5257					0.2210
Dec.	744	218	37	379	110	0.4409	0.6646					0.2168

During the whole study period, it was observed that availability during the January, February and March was high and ranges between 84.81% - 61.42%. This was primarily due to production pressure to reach the target production quantity of that financial year. More breakdowns were observed in the months of June, July and August i.e. in the rainy seasons and after the overused period of dump trucks in the production pressure months. These are the main reasons for low availability in this period which varies from 47.58% - 80.65%. In the month of October, November and December, there are many festivals in the North India i.e. Durga Pooja, Diwali, Chhat Pooja and Christmas. In these festive seasons employees want to enjoy the festivals with their family members which cause more idle time of the dump trucks. Hence, due to more idle time of the dump trucks, utilization decreases in these months and ranges from 51% - 81.47%.

Using the above methodology, the calculation of performance of other dump trucks described in section 5.1 has been calculated and is given in **APPENDIX-A** from Table A1 to Table A191.

5.3 Performance Analysis of the 85 T Dump Truck

Using the proposed methodology, the performance of 85 T dump trucks (C-587) has been calculated for the year 2017 and presented in Table 5.4.

Table 5.4 Description of A and U calculation for 85 T Dump Truck

Month	SFT	WRK	MNT	BDN	IDL	A%	U%
Jan-17	744	425	0	35	200	0.9531	0.7178
Feb-17	696	224	319	24	93	0.5074	0.7362
Mar-17	744	396	32	35	197	0.9095	0.7094
Apr-17	720	439	40	34	147	0.8973	0.7724
May-17	744	474	0	36	150	0.9513	0.7884
Jun-17	720	409	64	33	154	0.8655	0.7526
Jul-17	744	409	29	35	187	0.9144	0.7247
Aug-17	744	376	71	33	180	0.8595	0.7193
Sep-17	720	420	24	35	181	0.9180	0.7262
Oct-17	744	233	273	23	131	0.6017	0.7081
Nov-17	720	428	23	38	171	0.9148	0.7406
Dec-17	744	433	40	37	150	0.8967	0.7754

5.4 Comparison of A and U of 85 T and 100 T Dump Trucks

To do a comparative study of performance of dump trucks of different capacities, 100T dump truck (D-10630) and 85 T Dump truck (C-587) were selected. These two dump trucks are of same manufacturer, deployed in the same mine for similar tasks and have been operating in the mine for approximately equal operating hours.

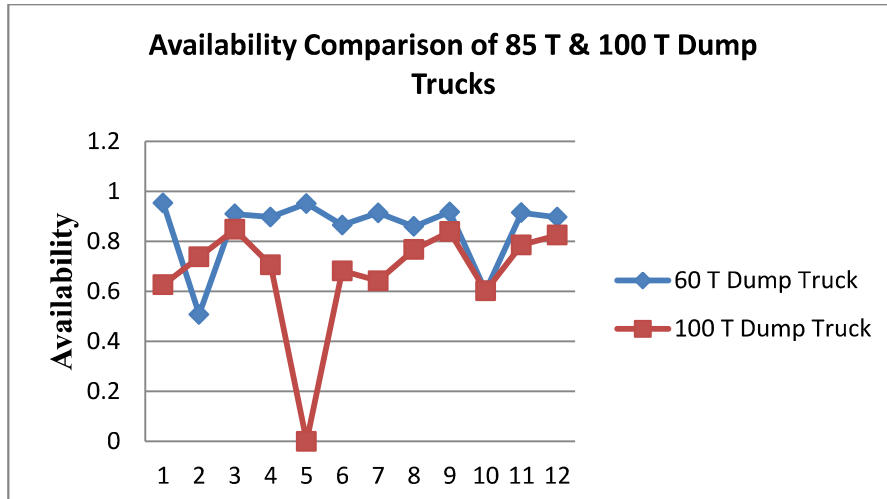


Figure 5.1 Availability Comparisons of 85 T and 100 T Dump Trucks

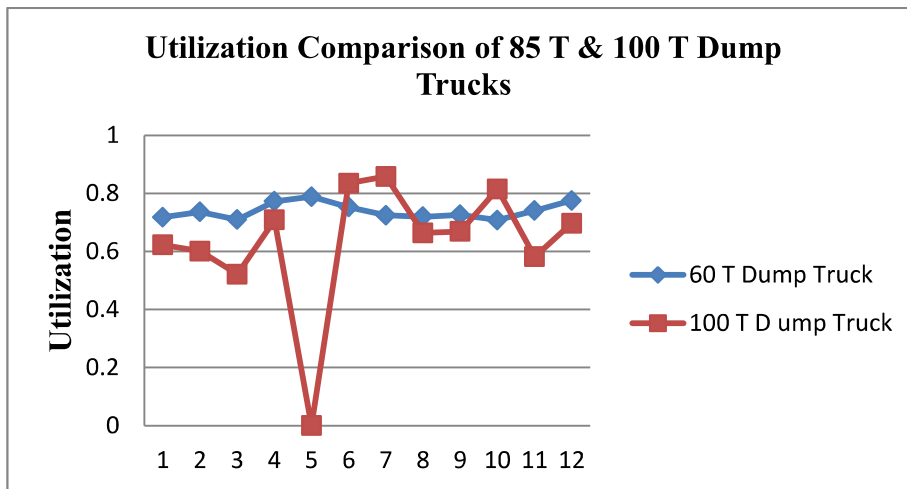


Figure 5.2 Utilization Comparisons of 85 T and 100 T Dump Trucks

It is clear from the above Table 5.1 and Table 5.4 and Figure 5.1 and Figure 5.2 that on average, availability performance of the 85 T capacity dump trucks is better than 100 T capacity dump trucks. This is primarily due to comparatively low downtime of 85 T dump trucks. It is also noticeable that utilization of the 85 T dump truck (C-587) is marginally higher than the 100 T dump truck D-10630. This implies that 85 T dump trucks are the management choice. Figure 5.1 and Figure 5.2, show that in the month of

May, availability and utilization of D-10630 dump truck dips to zero which is due to the major breakdown of the dump truck.

5.5 Benchmarking

Classification of dump trucks based on their performance characteristics helps to frame performance-specific recommendation. By analyzing the performance, one can assess the present performance level and accordingly decide the apt interventions following the recommendation for that performance level. Figure 5.3 (a) depicts the lines of demarcation between the clusters and this helps to classify the dump trucks based on their current performance status.

Calculated OEPI values of case studied dump trucks during the study period have been given in Table 5.5. Using k-means clustering, dump trucks' performance of each month has been categorized into five homogeneous clusters as presented in Table 5.6 (a) and Table 5.6 (b) for the month of January and February respectively. For the remaining months, the categorized performance has been given in the **APPENDIX-B** (Table B1 to Table B10). Support vector machine tool has been used to demarcate boundaries between the different homogeneous clusters generated by k-means clustering (**APPENDIX-C**, Table C1 to Table C12). These five clusters have been named as poor, marginal, average, moderate and good performance levels which have been shown in Figure 5.3 (a) for Overall Equipment Performance Indicator. Following the same methodology demarcation lines between the clusters of availability (A) and Utilization (U) have also been drawn and shown in Figure 5.3 (b) and Figure 5.3 (c) respectively for the month of January. Similarly, other Figures for A, U and OEPI for rest of the months have been given in **APPENDIX-D** in the Figures D1 to Figure D33.

Table 5.5 Calculated OEPI values of case studied dump trucks during the study period

Months	Calculated OEPI value before clustering
Jan.	0.29, 0.24, 0.24, 0.28, 0.20, 0.19, 0.32, 0.21, 0.20, 0.31, 0.18, 0.20, 0.25, 0.29, 0.26, 0.54, 0.38, 0.35, 0.55, 0.52, 0.30, 0.54, 0.30, 0.38, 0.51, 0.33, 0.27, 0.39, 0.27, 0.28, 0.24, 0.14, 0.29, 0.14, 0.30, 0.20, 0.16, 0.22, 0.23, 0.21, 0.17, 0.23, 0.20, 0.14, 0.18, 0.23, 0.20, 0.14, 0.18, 0.23, 0.17, 0.17, 0.17, 0.21, 0.24, 0.20, 0.19, 0.20, 0.22, 0.30, 0.32, 0.23, 0.27, 0.22, 0.23, 0.21, 0.25, 0.24, 0.22, 0.17, 0.21, 0.23, 0.26, 0.25, 0.23, 0.25, 0.21, 0.33, 0.25, 0.27, 0.23, 0.31, 0.26, 0.18, 0.21, 0.24, 0.17, 0.51, 0.35, 0.33, 0.55, 0.37, 0.29
Feb.	0.26, 0.23, 0.19, 0.25, 0.23, 0.14, 0.29, 0.20, 0.23, 0.06, 0.30, 0.12, 0.22, 0.20, 0.45, 0.39, 0.43, 0.51, 0.45, 0.26, 0.51, 0.34, 0.26, 0.37, 0.35, 0.51, 0.33, 0.26, 0.16, 0.12, 0.28, 0.14, 0.14, 0.28, 0.20, 0.33, 0.18, 0.18, 0.21, 0.14, 0.23, 0.19, 0.15, 0.21, 0.25, 0.17, 0.16, 0.19, 0.11, 0.15, 0.18, 0.17, 0.15, 0.26, 0.31, 0.28, 0.21, 0.18, 0.17, 0.28, 0.24, 0.13, 0.20, 0.28, 0.24, 0.22, 0.26, 0.16, 0.32, 0.20, 0.22, 0.27, 0.19, 0.20, 0.22, 0.32, 0.11, 0.27, 0.16, 0.26, 0.24, 0.26, 0.27, 0.31, 0.27, 0.19, 0.18, 0.14, 0.23, 0.35, 0.28, 0.27, 0.28, 0.24, 0.31, 0.19, 0.19, 0.24, 0.26, 0.27, 0.31, 0.26, 0.20, 0.19, 0.19, 0.51, 0.41, 0.32, 0.54, 0.41, 0.26
Mar.	0.11, 0.25, 0.21, 0.24, 0.19, 0.24, 0.32, 0.21, 0.20, 0.52, 0.19, 0.22, 0.19, 0.24, 0.50, 0.38, 0.32, 0.50, 0.33, 0.29, 0.55, 0.34, 0.27, 0.47, 0.24, 0.25, 0.50, 0.22, 0.24, 0.23, 0.12, 0.14, 0.28, 0.11, 0.18, 0.24, 0.22, 0.16, 0.14, 0.23, 0.23, 0.18, 0.13, 0.23, 0.18, 0.19, 0.15, 0.15, 0.20, 0.11, 0.31, 0.23, 0.18, 0.15, 0.25, 0.24, 0.27, 0.28, 0.24, 0.19, 0.29, 0.19, 0.20, 0.28, 0.24, 0.19, 0.27, 0.26, 0.27, 0.31, 0.22, 0.32, 0.29, 0.22, 0.26, 0.17, 0.22, 0.51, 0.35, 0.37, 0.51, 0.28, 0.29
Apr.	0.30, 0.21, 0.17, 0.15, 0.18, 0.18, 0.23, 0.19, 0.22, 0.31, 0.19, 0.23, 0.21, 0.31, 0.17, 0.51, 0.52, 0.21, 0.40, 0.50, 0.32, 0.41, 0.39, 0.29, 0.52, 0.52, 0.26, 0.22, 0.18, 0.17, 0.14, 0.13, 0.16, 0.13, 0.10, 0.12, 0.13, 0.07, 0.14, 0.13, 0.17, 0.14, 0.12, 0.19, 0.10, 0.22, 0.21, 0.25, 0.16, 0.16, 0.09, 0.18, 0.20, 0.19, 0.27, 0.17, 0.20, 0.21, 0.18, 0.22, 0.17, 0.24, 0.13, 0.21, 0.14, 0.26, 0.27, 0.31, 0.27, 0.19, 0.18, 0.14, 0.23, 0.35, 0.28, 0.27, 0.28, 0.24, 0.31, 0.19, 0.19, 0.24, 0.26, 0.31, 0.20, 0.25, 0.27, 0.20, 0.44, 0.24, 0.28, 0.44, 0.44, 0.18
May	0.11, 0.20, 0.24, 0.35, 0.17, 0.25, 0.20, 0.18, 0.25, 0.46, 0.23, 0.09, 0.19, 0.27, 0.39, 0.35, 0.05, 0.49, 0.26, 0.33, 0.21, 0.48, 0.46, 0.26, 0.48, 0.38, 0.33, 0.17, 0.11, 0.20, 0.16, 0.13, 0.26, 0.12, 0.16, 0.16, 0.17, 0.23, 0.17, 0.18, 0.18, 0.15, 0.21, 0.18, 0.21, 0.11, 0.15, 0.19, 0.20, 0.18, 0.22, 0.18, 0.15, 0.21, 0.22, 0.23, 0.20, 0.17, 0.14, 0.11, 0.27, 0.24, 0.21, 0.20, 0.20, 0.25, 0.15, 0.14, 0.27, 0.20, 0.21, 0.21, 0.37, 0.23, 0.20, 0.30, 0.30, 0.30, 0.11, 0.22, 0.27, 0.32, 0.19, 0.33, 0.28, 0.25, 0.41, 0.31, 0.26
Jun.	0.29, 0.19, 0.16, 0.33, 0.22, 0.35, 0.18, 0.17, 0.20, 0.23, 0.18, 0.32, 0.21, 0.21, 0.30, 0.35, 0.49, 0.49, 0.23, 0.55, 0.49, 0.17, 0.49, 0.49, 0.19, 0.46, 0.42, 0.25, 0.23, 0.14, 0.13, 0.31, 0.20, 0.15, 0.21, 0.17, 0.16, 0.15, 0.16, 0.15, 0.10, 0.23, 0.23, 0.18, 0.20, 0.18, 0.11, 0.15, 0.23, 0.12, 0.18, 0.14, 0.10, 0.27, 0.21, 0.16, 0.19, 0.17, 0.20, 0.12, 0.19, 0.31, 0.19, 0.17, 0.19, 0.24, 0.22, 0.24, 0.15, 0.25, 0.20, 0.19, 0.28, 0.29, 0.14, 0.28, 0.13, 0.15, 0.15, 0.35, 0.25, 0.20, 0.10, 0.25, 0.32, 0.21, 0.38, 0.43, 0.33, 0.42, 0.40
Jul.	0.19, 0.19, 0.24, 0.24, 0.15, 0.23, 0.19, 0.23, 0.23, 0.23, 0.26, 0.12, 0.18, 0.52, 0.50, 0.25, 0.48, 0.33, 0.23, 0.49, 0.42, 0.31, 0.47, 0.40, 0.13, 0.33, 0.37, 0.29, 0.18, 0.14, 0.10, 0.08, 0.11, 0.08, 0.13, 0.19, 0.16, 0.23, 0.20, 0.16, 0.16, 0.21, 0.18, 0.21, 0.11, 0.15, 0.23, 0.12, 0.18, 0.14, 0.10, 0.27, 0.21, 0.16, 0.19, 0.17, 0.20, 0.12, 0.19, 0.31, 0.19, 0.17, 0.19, 0.24, 0.22, 0.24, 0.15, 0.25, 0.20, 0.19, 0.28, 0.29, 0.14, 0.28, 0.13, 0.15, 0.15, 0.35, 0.25, 0.20, 0.10, 0.25, 0.32, 0.21, 0.38, 0.43, 0.33, 0.42, 0.40
Aug.	0.14, 0.18, 0.23, 0.14, 0.20, 0.17, 0.19, 0.21, 0.34, 0.33, 0.19, 0.20, 0.15, 0.52, 0.51, 0.50, 0.39, 0.29, 0.51, 0.50, 0.18, 0.52, 0.23, 0.48, 0.29, 0.19, 0.13, 0.11, 0.20, 0.13, 0.08, 0.30, 0.21, 0.09, 0.35, 0.15, 0.14, 0.23, 0.19, 0.17, 0.16, 0.25, 0.15, 0.18, 0.28, 0.11, 0.11, 0.24, 0.13, 0.12, 0.15, 0.20, 0.18, 0.20, 0.16, 0.29, 0.10, 0.19, 0.29, 0.13, 0.17, 0.28, 0.19, 0.17, 0.17, 0.16, 0.10, 0.15, 0.22, 0.29, 0.22, 0.16, 0.28, 0.28, 0.09, 0.27, 0.25, 0.16, 0.26, 0.14, 0.51, 0.53, 0.50, 0.50, 0.50, 0.47
Sep.	0.29, 0.38, 0.18, 0.42, 0.12, 0.26, 0.21, 0.10, 0.26, 0.16, 0.39, 0.19, 0.39, 0.50, 0.49, 0.27, 0.52, 0.49, 0.50, 0.49, 0.21, 0.51, 0.50, 0.22, 0.51, 0.50, 0.24, 0.16, 0.15, 0.12, 0.07, 0.27, 0.16, 0.16, 0.16, 0.29, 0.17, 0.17, 0.13, 0.17, 0.13, 0.13, 0.13, 0.18, 0.10, 0.36, 0.14, 0.09, 0.21, 0.36, 0.26, 0.19, 0.18, 0.18, 0.22, 0.15, 0.25, 0.20, 0.23, 0.19, 0.25, 0.16, 0.16, 0.18, 0.19, 0.16, 0.14, 0.22, 0.18, 0.20, 0.12, 0.19, 0.31, 0.24, 0.18, 0.29, 0.38, 0.20, 0.23, 0.27, 0.28, 0.21, 0.17, 0.25, 0.19, 0.49, 0.51, 0.49, 0.51, 0.48, 0.47
Oct.	0.21, 0.20, 0.22, 0.14, 0.28, 0.18, 0.45, 0.13, 0.20, 0.39, 0.23, 0.15, 0.36, 0.26, 0.12, 0.49, 0.18, 0.51, 0.50, 0.20, 0.51, 0.50, 0.18, 0.51, 0.48, 0.25, 0.49, 0.49, 0.17, 0.12, 0.14, 0.10, 0.27, 0.12, 0.17, 0.23, 0.23, 0.20, 0.15, 0.27, 0.15, 0.25, 0.14, 0.20, 0.17, 0.09, 0.19, 0.15, 0.17, 0.19, 0.16, 0.16, 0.30, 0.13, 0.15, 0.23, 0.23, 0.16, 0.13, 0.35, 0.19, 0.20, 0.25, 0.20, 0.19, 0.26, 0.17, 0.27, 0.12, 0.22, 0.32, 0.14, 0.19, 0.33, 0.35, 0.21, 0.30, 0.23, 0.21, 0.22, 0.22, 0.30, 0.28, 0.10, 0.29, 0.32, 0.17, 0.50, 0.49, 0.50, 0.49, 0.47
Nov.	0.22, 0.19, 0.17, 0.15, 0.20, 0.18, 0.24, 0.24, 0.19, 0.27, 0.24, 0.18, 0.26, 0.18, 0.50, 0.20, 0.50, 0.29, 0.51, 0.49, 0.22, 0.50, 0.49, 0.26, 0.49, 0.50, 0.27, 0.13, 0.14, 0.11, 0.16, 0.12, 0.23, 0.16, 0.19, 0.09, 0.13, 0.16, 0.16, 0.18, 0.23, 0.19, 0.16, 0.18, 0.15, 0.23, 0.10, 0.08, 0.14, 0.16, 0.26, 0.25, 0.19, 0.21, 0.12, 0.11, 0.20, 0.19, 0.18, 0.25, 0.19, 0.23, 0.31, 0.20, 0.20, 0.12, 0.16, 0.30, 0.26, 0.15, 0.32, 0.29, 0.16, 0.30, 0.24, 0.17, 0.29, 0.24, 0.28, 0.17, 0.21, 0.28, 0.27, 0.19, 0.50, 0.49, 0.49, 0.48
Dec.	0.24, 0.25, 0.19, 0.10, 0.19, 0.16, 0.30, 0.15, 0.17, 0.31, 0.24, 0.16, 0.29, 0.14, 0.51, 0.50, 0.53, 0.49, 0.24, 0.50, 0.22, 0.50, 0.49, 0.23, 0.49, 0.51, 0.23, 0.29, 0.19, 0.07, 0.19, 0.15, 0.18, 0.20, 0.15, 0.23, 0.16, 0.15, 0.22, 0.22, 0.22, 0.19, 0.13, 0.17, 0.26, 0.20, 0.15, 0.17, 0.18, 0.12, 0.24, 0.18, 0.20, 0.14, 0.18, 0.25, 0.17, 0.29, 0.13, 0.29, 0.20, 0.12, 0.29, 0.25, 0.36, 0.28, 0.14, 0.19, 0.17, 0.24, 0.27, 0.25, 0.18, 0.35, 0.12, 0.29, 0.34, 0.37, 0.25, 0.22, 0.25, 0.22, 0.26, 0.30, 0.20, 0.51, 0.49, 0.51, 0.50, 0.48, 0.49

Table 5.6 (a) Performance Clusters of OEPI values for the month of January

Performance Level	OEPI Data after clustering
Poor	0.19, 0.18, 0.14, 0.14, 0.16, 0.18, 0.17, 0.18, 0.17, 0.12, 0.12, 0.14, 0.18, 0.17, 0.17, 0.17, 0.19, 0.17, 0.18, 0.17
Marginal	0.24, 0.24, 0.20, 0.21, 0.20, 0.20, 0.25, 0.24, 0.22, 0.23, 0.21, 0.23, 0.23, 0.20, 0.23, 0.21, 0.24, 0.20, 0.20, 0.22, 0.23, 0.22, 0.23, 0.21, 0.25, 0.24, 0.22, 0.21, 0.23, 0.26, 0.25, 0.23, 0.25, 0.21, 0.25, 0.23, 0.26, 0.21, 0.24
Average	0.29, 0.28, 0.32, 0.31, 0.29, 0.30, 0.30, 0.33, 0.27, 0.27, 0.28, 0.29, 0.30, 0.30, 0.32, 0.27, 0.33, 0.30, 0.27, 0.31, 0.33, 0.29
Moderate	0.35, 0.38, 0.39, 0.35, 0.37
Good	0.54, 0.55, 0.52, 0.54, 0.51, 0.51, 0.55

Table 5.6 (b) Performance Clusters of OEPI values for the month of February

Performance Level	OEPI Data after clustering
Poor	0.14, 0.06, 0.12, 0.16, 0.12, 0.14, 0.14, 0.14, 0.15, 0.15, 0.16, 0.11, 0.15, 0.15, 0.13, 0.16, 0.11, 0.16
Marginal	0.21, 0.19, 0.23, 0.23, 0.20, 0.23, 0.22, 0.20, 0.20, 0.18, 0.18, 0.21, 0.19, 0.19, 0.21, 0.17, 0.19, 0.18, 0.17, 0.21, 0.18, 0.17, 0.20, 0.22, 0.20, 0.22, 0.19, 0.20, 0.22, 0.20, 0.19, 0.19
Average	0.26, 0.29, 0.30, 0.26, 0.34, 0.26, 0.33, 0.26, 0.28, 0.28, 0.33, 0.26, 0.25, 0.26, 0.31, 0.28, 0.28, 0.24, 0.28, 0.26, 0.32, 0.27, 0.32, 0.27, 0.28, 0.26, 0.24, 0.26, 0.27, 0.31, 0.26, 0.32, 0.26
Moderate	0.45, 0.39, 0.43, 0.45, 0.37, 0.35, 0.41, 0.41
Good	0.51, 0.51, 0.51, 0.51, 0.54

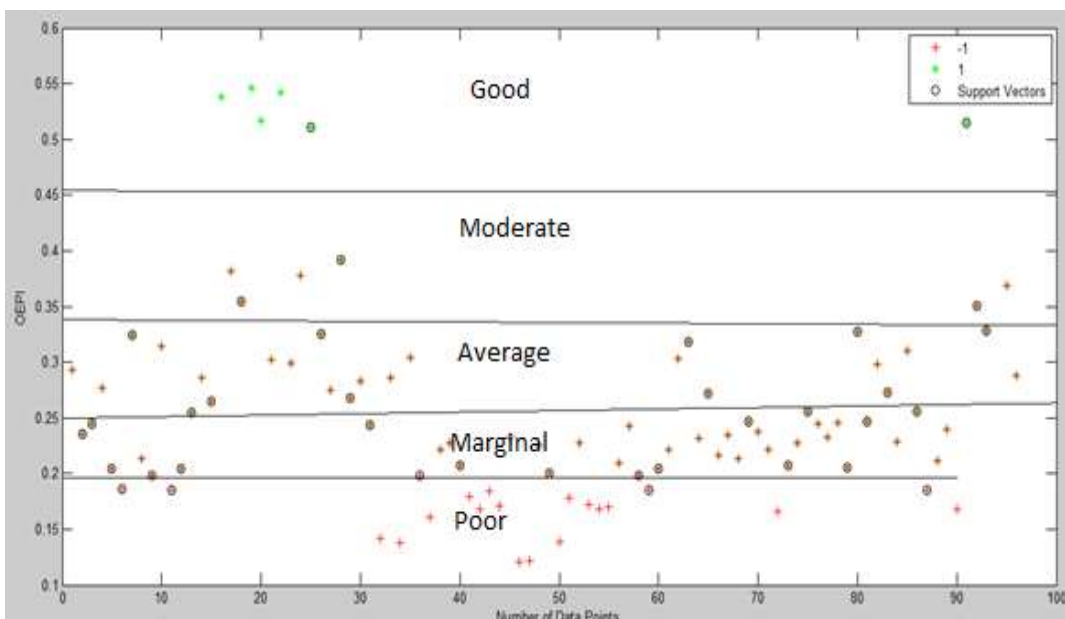


Figure 5.3 (a) Clustering and demarcation of the OEPI for the month of January

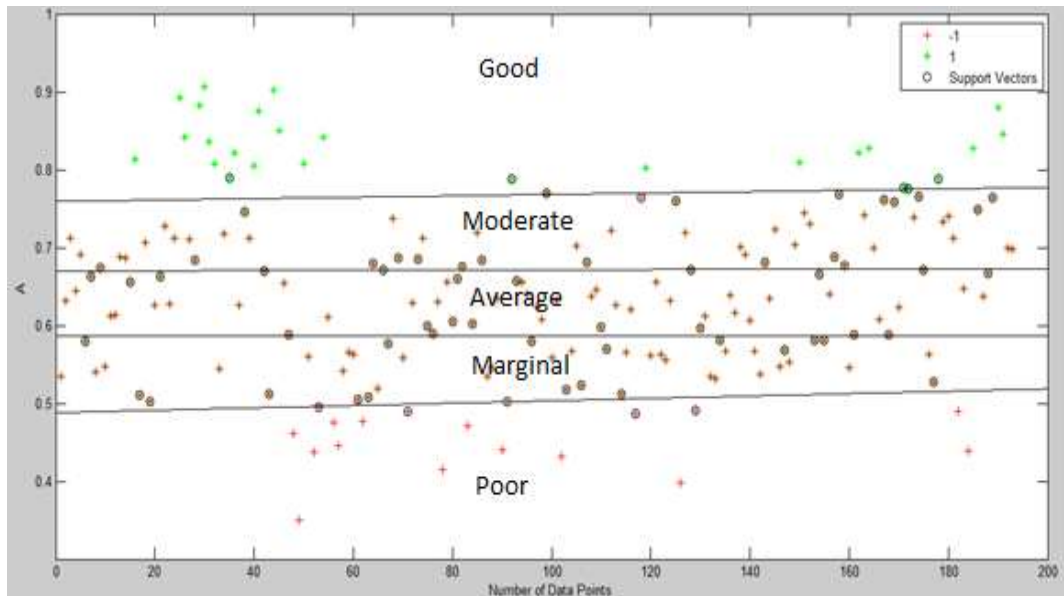


Figure 5.3 (b) Clustering and demarcation of the A data for the month of January

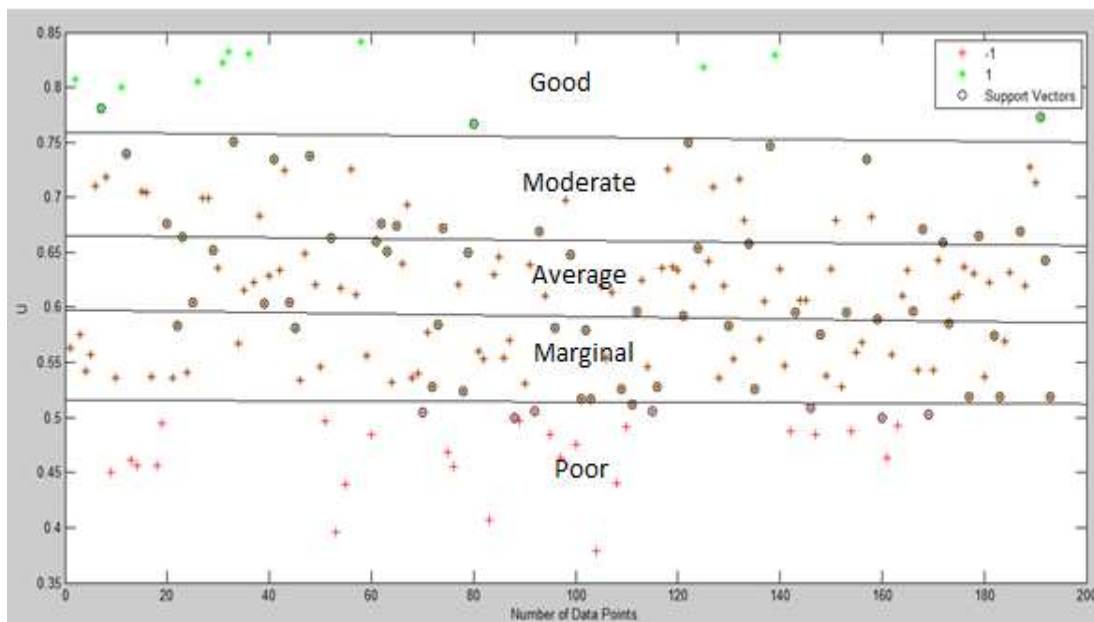


Figure 5.3 (c) Clustering and demarcation of the U data for the month of January

Table 5.7 is describing the range of different performance categories i.e., poor, marginal, average, moderate and good performance levels of A, U and OEPI for the month of January. By comparing the performance of any dump truck in the month of

January, anyone can easily predict that particular dump truck belongs into which group of performance level and accordingly action for the further improvement can be taken.

Table 5.7 Range of different performance level for the month of January

	A	U	OEPI
Poor	0 – 0.50	0 – 0.52	0 – 0.19
Marginal	0.51 – 0.58	0.53 – 0.59	0.20 – 0.26
Average	0.59 – 0.67	0.60 – 0.66	0.27 – 0.34
Moderate	0.68 – 0.77	0.67 – 0.76	0.35 – 0.45
Good	Above 0.77	Above 0.76	Above 0.45

5.5.1 Analysis of Benchmarked values

Table 5.8 Benchmarking values of A, U and OEPI month wise

Months	BM value of A	BM value of U	BM value of OEPI
January	0.83	0.81	0.53
February	0.86	0.85	0.52
March	0.84	0.79	0.54
April	0.79	0.78	0.51
May	0.80	0.90	0.47
June	0.83	0.85	0.50
July	0.80	0.78	0.48
August	0.84	0.78	0.50
September	0.83	0.79	0.50
October	0.89	0.76	0.49
November	0.90	0.73	0.50
December	0.85	0.79	0.50

Following the methodology described in Chapter 3 section 3.2, benchmark values of 100 T dump trucks has been established as given in Table 5.8. The benchmarked value of A, U and OEPI are kept high for the month of January, February and March. These months belong to production quarter and comparatively higher performance levels are important to achieve the target production of that financial year.

In the month of April, both A and U are low as compared to other months. Availability is low as the dump trucks are sometimes overused in the previous quarter even ignoring minor repairs and sometimes scheduled maintenance is deferred. Due to the relaxed atmosphere just after the highly stressed production quarter, utilization level of dump trucks decreases.

A high benchmarked value of U for the month of May indicates high energy level of personnel after the relaxed period and work with full potential.

Most of the machines are repaired and get their schedule maintenance by the month of June. Therefore, A is maintained at high as the management wishes to utilize the dump trucks to their maximum to produce as much coal as possible before the start of rainy season.

In the month of July, A and U are poor due to peak of rainy season.

In the month of August, availability of dump trucks is good primarily due to underutilization during rainy season and good maintenance but sometimes utilization suffers due to unavailability of blasted coal, damaged haul-road etc.

After mid-September, weather starts changing and management start to utilize the dump trucks for increasing the production whereas due to poor haul-road condition breakdown also occurs which decreases A slightly.

October and November are the festive seasons in the North India (in NCL region) which lowers the U due to large absentees.

In the month of December, utilization increases as the management wish to produce more due to the increasing pressure of achieving the target production.