CHAPTER 6 RESULTS AND DISCUSSION THROUGH PARAMETRIC ANALYSIS IN THE CASE STUDIES

This research study was done to access the amount of coal exposure, the amount of rehandling, the rate of linear advancement, and sectional volumes excavated by draglines according to their productivity in different geo-mining conditions and mode of operation with different machine combinations. After the development of three-dimensional balancing diagram and its validation, an analysis was carried out to determine how various geo-mining, operational and machine parameters influenced the rate of coal exposure and percentage rehandle, by varying one parameter at a time and keeping all other parameters constant. It is worth mentioning that the efficiency of tandem dragline operation is measured by evaluating the rehandling percentage of overburden and rate of coal exposure by the dragline. This pre-requisite is necessary to understand the influence of important parameters, since dragline operation is very intricate and involves the interaction of many operational, geological and machine parameters. The various situations that will be covers are as follows.

(i) Annual production of leading dragline is less than the capacity of lagging dragline (Le<La)

(ii) Annual production of leading and lagging dragline are same (Le=La)

(iii) Annual production of leading dragline is greater than the capacity of lagging dragline (Le>La)

(iv) Influence of cut width

(v) Influence of stripping bench height

(vi) Influence of seam thickness

(vii) Influence of seam gradient

(viii) To find the best combination of cut width and bench height within the possible working range of draglines

(ix) Economics of dragline operation

The results obtained are discussed in this chapter one by one below.

6.1 Annual production of leading dragline is less than the annual production of lagging dragline

All the parameters, such as, high wall angle (70°), angle of repose (38°), bench slope angle (60°), coal seam gradient (2°), coal seam thickness (15 m), density of coal (1.52 te/m^3), coal recovery (90%), bench height (32 m), cut width (90 m), and utilization have been kept constant. In the field, the productivity of draglines has been observed to be diverse. A range of draglines from 1.8 Mm^3 to 4.8 Mm^3 annual production output were employed in the case studies and served as the basis of this research. The results have been given in table 6.1.1 for horizontal tandem, table 6.1.2 for vertical tandem mode-1, and table 6.1.3 for vertical tandem mode-2 for each variation in terms of coal exposure, percentage rehandle and linear advancement of the draglines. A typical three-dimensional balancing diagram is illustrated in figure 6.1.1 and the other diagrams are available in the Appendix 3 (figure 6.1.2 to 6.1.6). For all three modes of tandem dragline operation a comparison of important parameters like rate of coal exposure, percentage rehandle, and linear advancement of dragline per year are graphically represented in figure 6.1, 6.2 and 6.3. A ratio of leading to lagging dragline annual production capacity is taken in the above figures.

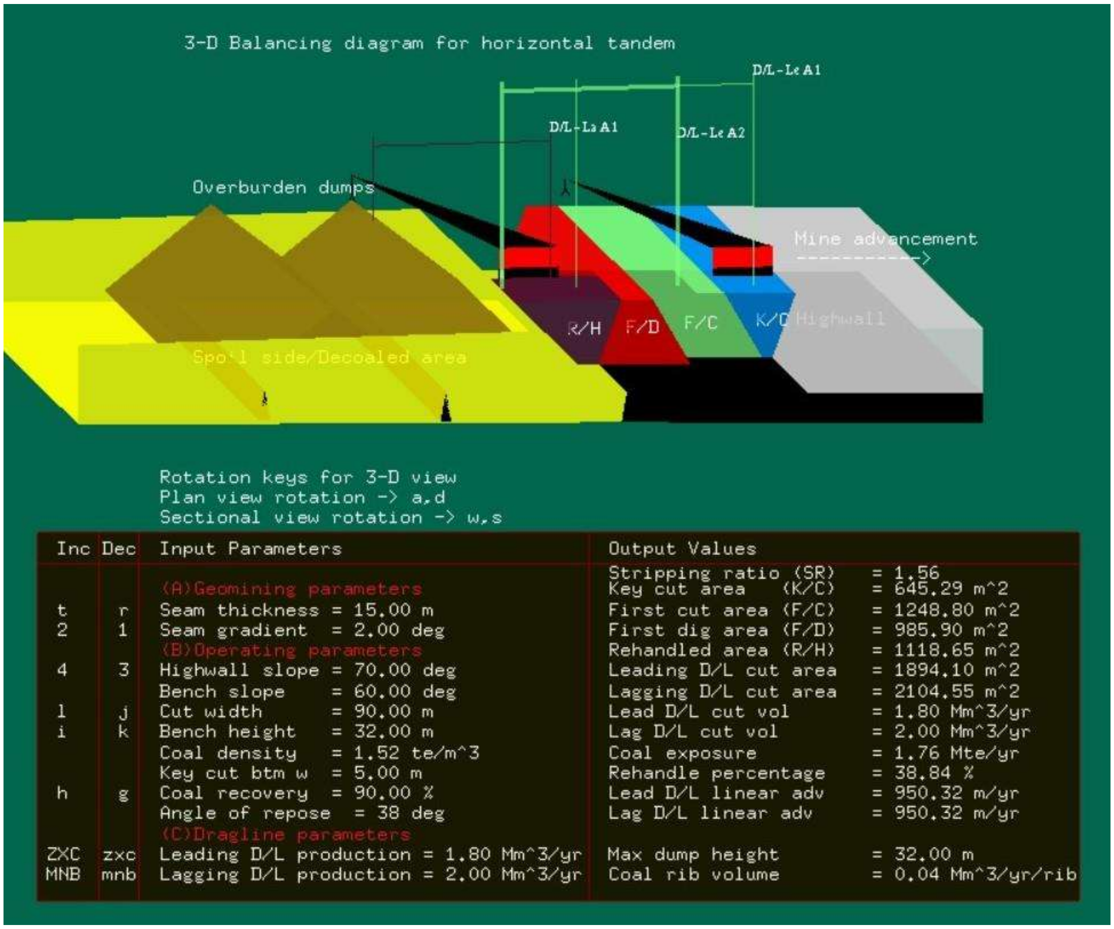

Figure 6.1.1: Three-dimensional balancing diagram for 1.80 Mm^3 leading and 2.00 Mm^3 lagging dragline.

Table 6.1.1: Performance in horizontal tandem when annual production of leading dragline is less than lagging dragline.

Sl No.	Leading dragline (Mm^3/ year)	Lagging dragline (Mm^3/ year)	Key cut Area (K/C) (m^2)	First cut Area (F/C) (m^2)	First dig Area (F/D) (m^2)	Rehandled Area (R/H) (m^2)	Coal exposure (Mte/ year)	% Rehandle	Linear advancement Of Leading/ Lagging dragline (m/year)
1	1.80	2.00	645.29	1248.80	985.90	1118.65	1.76	38.84	950.32
2	2.20	2.40	645.29	1267.10	967.60	1118.65	2.12	38.84	1150.39
3	2.60	2.80	645.29	1279.98	954.73	1118.65	2.49	38.84	1350.46
4	3.00	3.20	645.29	1289.54	945.17	1118.65	2.86	38.84	1550.52
5	3.40	3.60	645.29	1296.91	937.80	1118.65	3.23	38.84	1750.59
6	3.80	4.00	645.29	1302.76	931.94	1118.65	3.60	38.84	1950.66
7	4.20	4.40	645.29	1307.53	927.17	1118.65	3.97	38.84	2150.73
8	4.60	4.80	645.29	1311.49	923.22	1118.65	4.34	38.84	2350.80

Table 6.1.2: Performance in vertical tandem mode-1 when annual production of leading dragline is less than lagging dragline.

Sl No.	Leading dragline (Mm^3/ year)	Lagging dragline (Mm^3/ year)	Top cut area (T/C) (m^2)	Key cut area (K/C) (m^2)	First dig area (F/D) (m^2)	Rehandled area (R/H) (m^2)	Coal exposure (Mte/ year)	% Rehandle	Linear advancement of leading/ lagging dragline (m/year)	Upper bench + lower bench (m)
1	1.80	2.00	1334.25	225.67	1320.08	413.16	2.13	14.35	1153.91	14.82 +17.18
2	2.20	2.40	1349.96	221.97	1308.06	406.76	2.58	14.12	1399.55	15.00 +17.00
3	2.60	2.80	1360.98	219.39	1299.63	402.30	3.04	13.97	1645.18	15.12 +16.88
4	3.00	3.20	1369.13	217.50	1293.37	399.02	3.49	13.85	1890.80	15.21 +16.79
5	3.40	3.60	1375.41	216.04	1288.55	396.50	3.95	13.77	2136.42	15.28 +16.72
6	3.80	4.00	1380.39	214.89	1284.73	394.51	4.40	13.70	2382.03	15.34 +16.66
7	4.20	4.40	1384.44	213.95	1281.61	392.89	4.85	13.64	2627.64	15.38 +16.62
8	4.60	4.80	1387.80	213.18	1279.03	391.55	5.31	13.60	2873.25	15.42 +16.58

Table 6.1.3: Performance in vertical tandem mode-2 when annual production of leading dragline is less than lagging dragline.

Sl No.	Leading dragline (Mm^3/ year)	Lagging dragline (Mm^3/ year)	Top cut area (T/C) (m^2)	Key cut area (K/C) (m^2)	First dig area (F/D) (m^2)	Rehandled area (R/H) (m^2)	Coal exposure (Mte/ year)	% Rehandle	Linear advancement of leading/ lagging dragline (m/year)	Upper bench + lower bench (m)
1	1.80	2.00	1524.65	182.78	1172.58	338.70	2.18	11.76	1180.60	16.94 +15.06
2	2.20	2.40	1537.16	180.11	1162.74	334.03	2.64	11.60	1431.21	17.08 +14.92
3	2.60	2.80	1545.94	178.24	1155.82	330.78	3.11	11.49	1681.83	17.18 +14.82
4	3.00	3.20	1552.44	176.87	1150.69	328.38	3.57	11.40	1932.44	17.25 +14.75
5	3.40	3.60	1557.46	175.81	1146.73	326.53	4.03	11.34	2183.04	17.31 +14.69
6	3.80	4.00	1561.45	174.98	1143.58	325.07	4.49	11.29	2433.64	17.35 +14.65
7	4.20	4.40	1564.69	174.30	1141.02	323.88	4.96	11.25	2684.24	17.39 +14.61
8	4.60	4.80	1567.38	173.73	1138.89	322.90	5.42	11.21	2934.84	17.42 +14.58

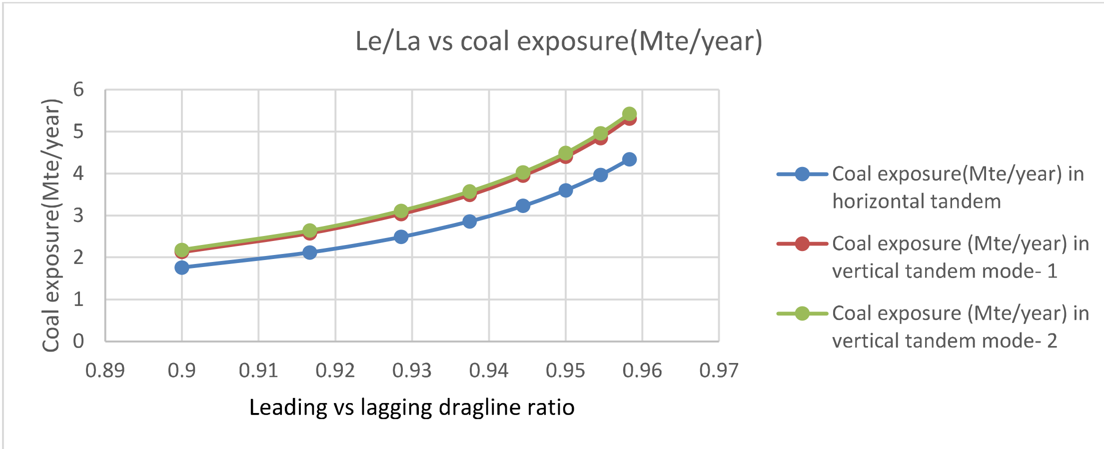

Figure 6.1: Le/La vs rate of coal exposure (Mte/year) in all three modes of tandem dragline operation.

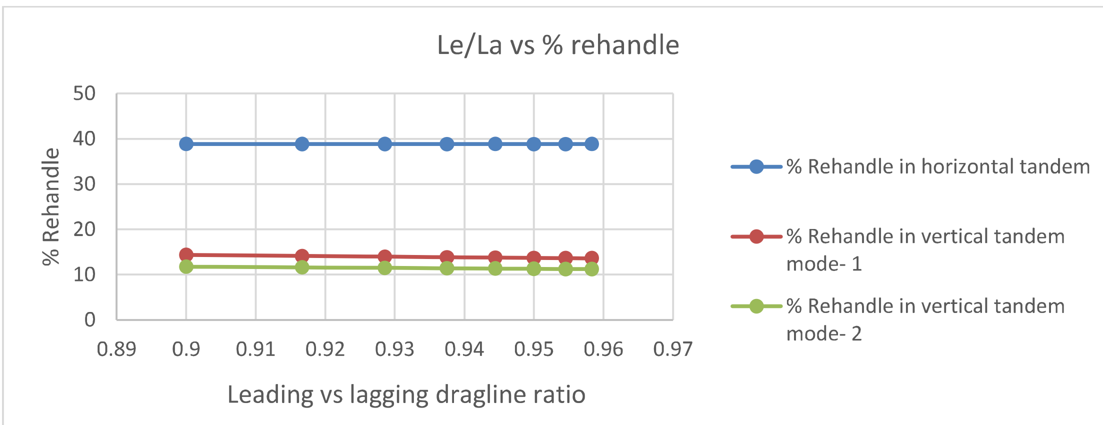

Figure 6.2: Le/La vs % rehandle in all three modes of tandem dragline operation.

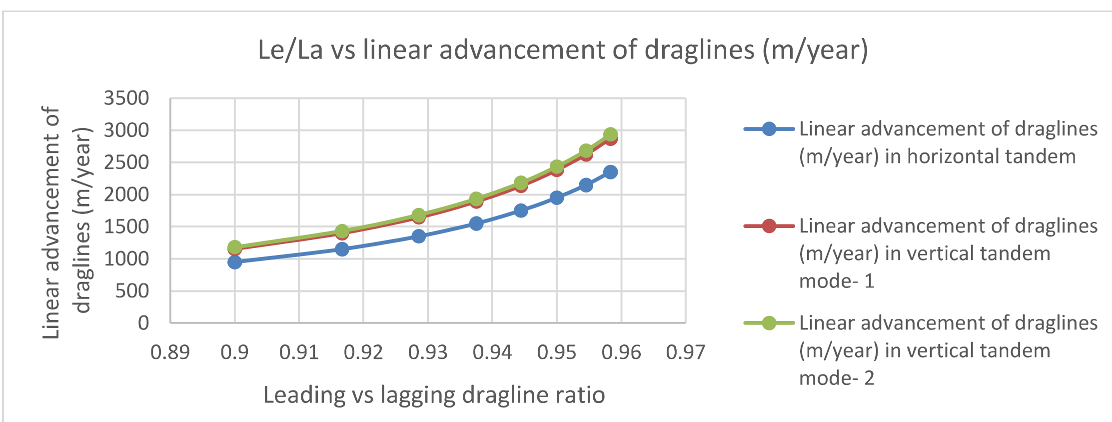

Figure 6.3: Le/La vs linear advancement of draglines (m/year) in all three modes of tandem dragline operation.

From these figures and table, following conclusions can be drawn.

(i) As the capacity of either or both draglines increase, the coal exposure in each type of tandem operation also goes up because bench height and cut width are constant, hence cross-sectional area of overburden remains constant. As the capacity of draglines increases, its linear advancement also increases.

(ii) Vertical tandem operation leads to increased coal exposure in comparison to horizontal tandem operation due to stripping bench division in vertical tandem leads to reduction in bench height of lower bench on which lagging dragline is deployed to excavate as well as rehandle the overburden. The cross-sectional area of rehandle, percentage of rehandle, and amount of unproductive work of the dragline all decreased, and this led to an increased rate of coal exposure.

(iii) The vertical tandem operation mode 2 has a greater rate of coal exposure in comparison to mode 1 due to a further decrease in the lower bench height on which the lagging dragline is positioned. Reduction in lower bench height decreases the amount of unproductive work, allowing the dragline to be more productive and thus increase the rate of coal exposure more than in mode 1.

(iv) Irrespective of the capacity of the dragline, percentage rehandle remains the same in horizontal tandem operation due to the constant bench height and cut width in all cases. This is because the bench slope angle for loose rock, angle of repose, berm clearance and coal rib left for full height are kept constant in the design, which gives a consistent cross-sectional area of rehandle, thus keeping the percentage rehandle the same.

(v) The amount of rehandling of material is greatly reduced in a vertical tandem compared to a horizontal tandem, since the stripping bench is divided into an upper and lower bench based on the annual production of draglines being used on each bench. The stripping bench is divided and the height of the bench on which the lagging dragline operates to dig and rehandle material (in the extended bench method) is lowered, thus decreasing the cross-sectional area of the rehandle and diminishing the amount of rehandling.

(vi) The percentage of rehandling is significantly lower in vertical tandem operation mode 2 than in mode 1 due to the further decrease in lower bench height in mode 2, where the lagging dragline works. Mode 1 involves the leading dragline not only excavating the upper bench (top cut), but also a key cut in the lower bench (refer to Appendix 3, figures 6.1.3 to 6.1.4). This means work of the leading dragline is distributed in both the upper and lower benches both whereas in mode 2, the leading dragline excavates only upper bench (top cut) (refer to Appendix 3, figures 6.1.5 to 6.1.6). Consequently, in order for both draglines to progress linearly, the leading dragline has to take on more of the total height of the bench, meaning a larger upper bench and a smaller lower bench. This decrease in the lower bench height leads to a smaller cross-sectional area for the rehandle, resulting in a lower percentage of rehandle.

(vii) When the ratio between the leading and lagging dragline capacity is reduced in both types of vertical tandem operation, the thickness of the lower bench increases, resulting in a higher percentage of rehandling.

The following points can be inferred from the above discussion:

(i) With increase in annual production capacity of either or both draglines, the rate of coal exposure in all three tandem operations also increases.

(ii) In horizontal tandem operation, the percentage of rehandle remains the same under the same operational and geological conditions regardless of the dragline capacity, while the percentage of rehandle varies in vertical tandem operation according to the capacity of the draglines used.

(iii) A vertical tandem system yields beneficial outcomes in regard to the amount of coal that is exposed and the percentage of it that needs to be rehandled.

(iv) It has been noticed that dragline operating in vertical mode 2 (where the leading dragline is used to excavate only the upper bench) brings about more positive results than mode 1 (where the leading dragline excavates the upper bench and the key cut in the lower bench).

(v) The amount of material rehandled is higher in a vertical tandem operation if the lagging dragline's capacity is increased, but it decreases if the leading dragline's capacity is increased.

(vi) The width of the cut should be determined considering the maximum reach of the leading dragline, particularly when it is used in vertical tandem, while keeping in mind the necessary clearance of the upper bench's toe.

It is important to recognize that how the mode of operation will influence the rate of coal exposure and amount of rehandle. If the mode of operation is changed from horizontal tandem to vertical tandem or from vertical tandem mode 1 to mode 2, the amount of coal exposure will go up while the amount of rehandle goes down. Bearing these fundamentals in mind, vertical tandem operation mode 2 is the best option.

6.2 Annual production capacity of leading and lagging dragline are same

All the parameters, such as, high wall angle (70°), angle of repose (38°), bench slope angle (60°), coal seam gradient (2°), coal seam thickness (15 m), density of coal (1.52 te/m^3), coal recovery (90%), bench height (32 m), cut width (90 m), and utilization have been kept constant. In the field, the productivity of draglines has been observed to be diverse. A range of draglines from 1.8 Mm^3 to 4.6 Mm^3 annual production output were employed in the case studies and served as the basis of this research.

The results have been given in table 6.2.1 for horizontal tandem, table 6.2.2 for vertical tandem mode-1, and table 6.2.3 for vertical tandem mode-2 for each variation in terms of coal exposure, percentage rehandle and linear advancement of the draglines. A typical three -dimensional balancing diagram is illustrated in figure 6.2.1 and the other diagrams are available in the appendix 3 (figures 6.2.2 to 6.2.6).

For all three modes of tandem dragline operation, a summary of important parameters like rate of coal exposure, percentage rehandle, and linear advancement of dragline per year are graphically represented in figure 6.4, 6.5 and 6.6. Most of the observations made are similar to those outlined previously, with the exception of a few. The exception is that in both types of vertical tandem operation, the percentage of rehandle is the same even though the capacity of both the draglines is increased. Due to the same capacity, the ratio of bench division remains the same, resulting in the same percentage rehandle.

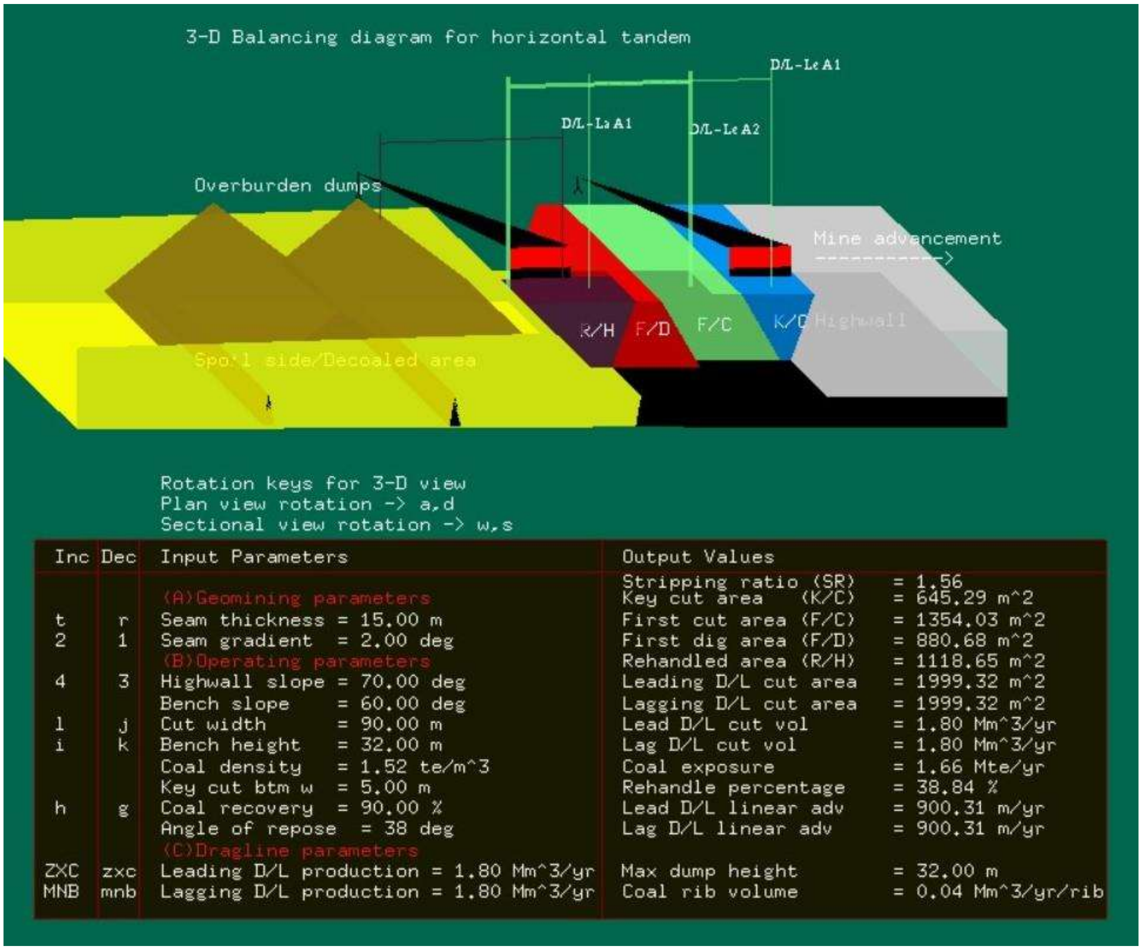

Figure 6.2.1: Three-dimensional balancing diagram for 1.80 Mm^3 leading and 1.80 Mm^3 lagging dragline.

Table 6.2.1: Performance in horizontal tandem when annual production of leading and lagging dragline are same.

Sl No.	Leading dragline (Mm^3/ year)	Lagging dragline (Mm^3/ year)	Key cut Area (K/C) (m^2)	First cut Area (F/C) (m^2)	First dig Area (F/D) (m^2)	Rehandled Area (R/H) (m^2)	Coal exposure (Mte/ year)	% Rehandle	Linear advancement Of Leading/ Lagging dragline (m/year)
1	1.80	1.80	645.29	1354.03	880.68	1118.65	1.66	38.84	900.31
2	2.20	2.20	645.29	1354.03	880.68	1118.65	2.03	38.84	1100.37
3	2.60	2.60	645.29	1354.03	880.68	1118.65	2.40	38.84	1300.44
4	3.00	3.00	645.29	1354.03	880.68	1118.65	2.77	38.84	1500.51
5	3.40	3.40	645.29	1354.03	880.68	1118.65	3.14	38.84	1700.58
6	3.80	3.80	645.29	1354.03	880.68	1118.65	3.51	38.84	1900.64
7	4.20	4.20	645.29	1354.03	880.68	1118.65	3.88	38.84	2100.71
8	4.60	4.60	645.29	1354.03	880.68	1118.65	4.25	38.84	2300.78

Table 6.2.2: Performance in vertical tandem mode-1 when annual production of leading and lagging dragline are same.

Sl No.	Leading dragline (Mm^3/ year)	Lagging dragline (Mm^3/ year)	Top cut area (T/C) (m^2)	Key cut area (K/C) (m^2)	First dig area (F/D) (m^2)	Rehandled area (R/H) (m^2)	Coal exposure (Mte/ year)	% Rehandle	Linear advancement of leading/ lagging dragline (m/year)	Upper bench + lower bench (m)
1	1.80	1.80	1423.69	204.99	1251.32	377.35	2.04	13.10	1105.19	15.82 +16.18
2	2.20	2.20	1423.69	204.99	1251.32	377.35	2.49	13.10	1350.79	15.82 +16.18
3	2.60	2.60	1423.69	204.99	1251.32	377.35	2.95	13.10	1596.38	15.82 +16.18
4	3.00	3.00	1423.69	204.99	1251.32	377.35	3.40	13.10	1841.98	15.82 +16.18
5	3.40	3.40	1423.69	204.99	1251.32	377.35	3.86	13.10	2087.58	15.82 +16.18
6	3.80	3.80	1423.69	204.99	1251.32	377.35	4.31	13.10	2333.17	15.82 +16.18
7	4.20	4.20	1423.69	204.99	1251.32	377.35	4.76	13.10	2578.77	15.82 +16.18
8	4.60	4.60	1423.69	204.99	1251.32	377.35	5.22	13.10	2824.37	15.82 +16.18

Table 6.2.3: Performance in vertical tandem mode-2 when annual production of leading and lagging dragline are same.

Sl No.	Leading dragline (Mm^3/ year)	Lagging dragline (Mm^3/ year)	Top cut area (T/C) (m^2)	Key cut area (K/C) (m^2)	First dig area (F/D) (m^2)	Rehandled area (R/H) (m^2)	Coal exposure (Mte/ year)	% Rehandle	Linear advancement of leading/ lagging dragline (m/year)	Upper bench + lower bench (m)
1	1.80	1.80	1596.21	167.75	1116.04	312.42	2.08	10.85	1127.67	17.74 +14.26
2	2.20	2.20	1596.21	167.75	1116.04	312.42	2.55	10.85	1378.26	17.74 +14.26
3	2.60	2.60	1596.21	167.75	1116.04	312.42	3.01	10.85	1628.85	17.74 +14.26
4	3.00	3.00	1596.21	167.75	1116.04	312.42	3.47	10.85	1879.45	17.74 +14.26
5	3.40	3.40	1596.21	167.75	1116.04	312.42	3.93	10.85	2130.04	17.74 +14.26
6	3.80	3.80	1596.21	167.75	1116.04	312.42	4.40	10.85	2380.63	17.74 +14.26
7	4.20	4.20	1596.21	167.75	1116.04	312.42	4.86	10.85	2631.22	17.74 +14.26
8	4.60	4.60	1596.21	167.75	1116.04	312.42	5.32	10.85	2881.82	17.74 +14.26

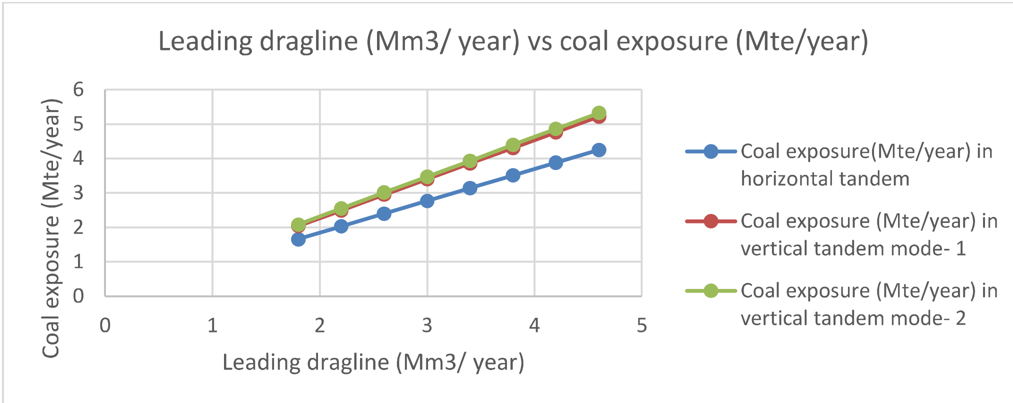

Figure 6.4: Annual production of leading dragline vs rate of coal exposure (Mte/year) in all three modes of tandem dragline operation.

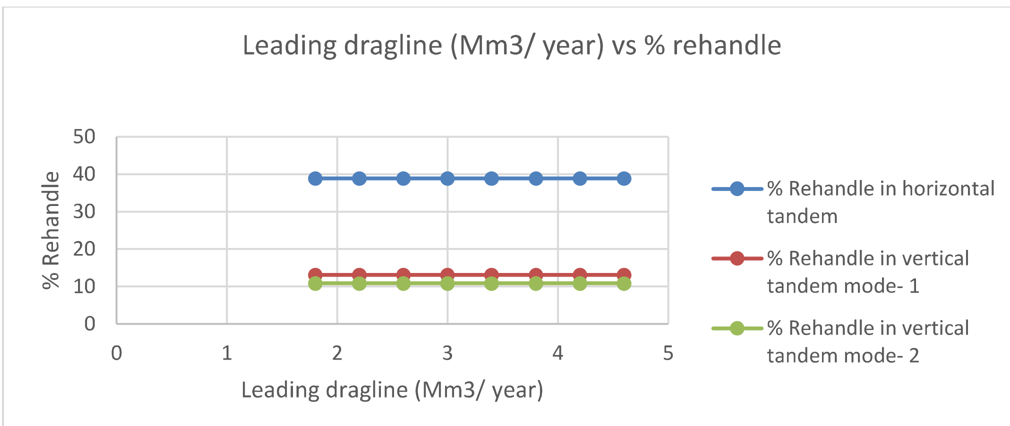

Figure 6.5: Annual production of leading dragline vs % rehandle in all three modes of tandem dragline operation.

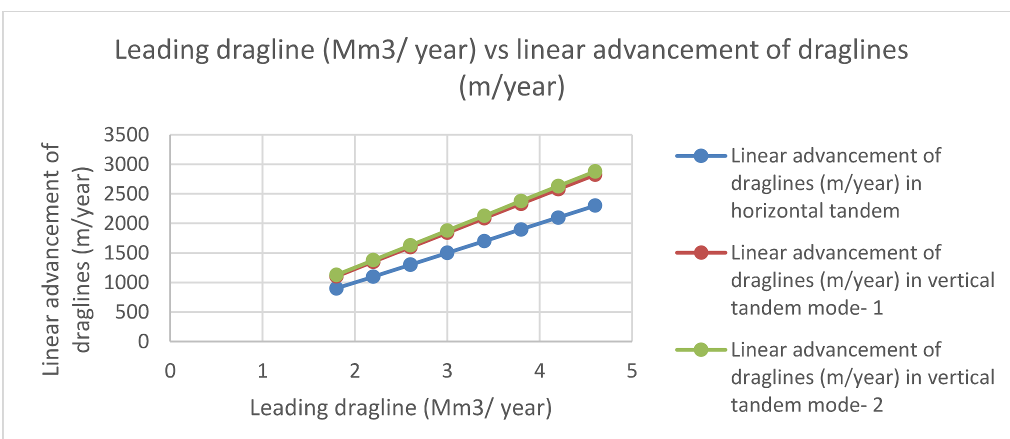

Figure 6.6: Annual production of leading dragline vs linear advancement of draglines (m/year) in all three modes of tandem dragline operation.

6.3 Annual production capacity of leading dragline is greater than the annual production capacity of lagging dragline

All the parameters, such as, high wall angle (70°), angle of repose (38°), bench slope angle (60°), coal seam gradient (2°), coal seam thickness (15 m), density of coal (1.52 te/m^3), coal recovery (90%), bench height (32 m), cut width (90 m), and utilization have been kept constant. The results have been given in table 6.3.1 for horizontal tandem, table 6.3.2 for vertical tandem mode-1, and table 6.3.3 for vertical tandem mode-2 for each variation in terms of coal exposure, percentage rehandle and linear advancement of the draglines. A typical three -dimensional balancing diagram is illustrated in figure 6.3.1 and the other diagrams are available in the Appendix 3 (figures 6.3.2 to 6.3.6).

For all three modes of tandem dragline operation, a summary of important parameters like rate of coal exposure, percentage rehandle, and linear advancement of dragline per year are graphically represented in figure 6.7, 6.8 and 6.9. A ratio of leading to lagging dragline annual production capacity is taken in the figure 6.7, 6.8 and 6.9.

The analysis of the figures and tables provided yields similar results to those mentioned in Section 6.1. A few notable findings are:

(i) The rate of coal exposure is higher in both the vertical tandem modes when the capacity of the leading dragline is lower than that of the lagging dragline (as obtained in case 6.1). This is due to the lower height of the lower bench in order to evenly divide the workload between the draglines and the corresponding lower percentage of rehandling.

(ii) The figures 6.3.2 to 6.3.6 in appendix 3 demonstrate that the reach of the lagging dragline placed on the spoil side is not enough, as the toe of the dumped material overlaps the rehandle area. To address this issue, the lagging dragline can be placed further away from the high wall, however this would lead to reduced effectiveness and a larger swing angle must be used.

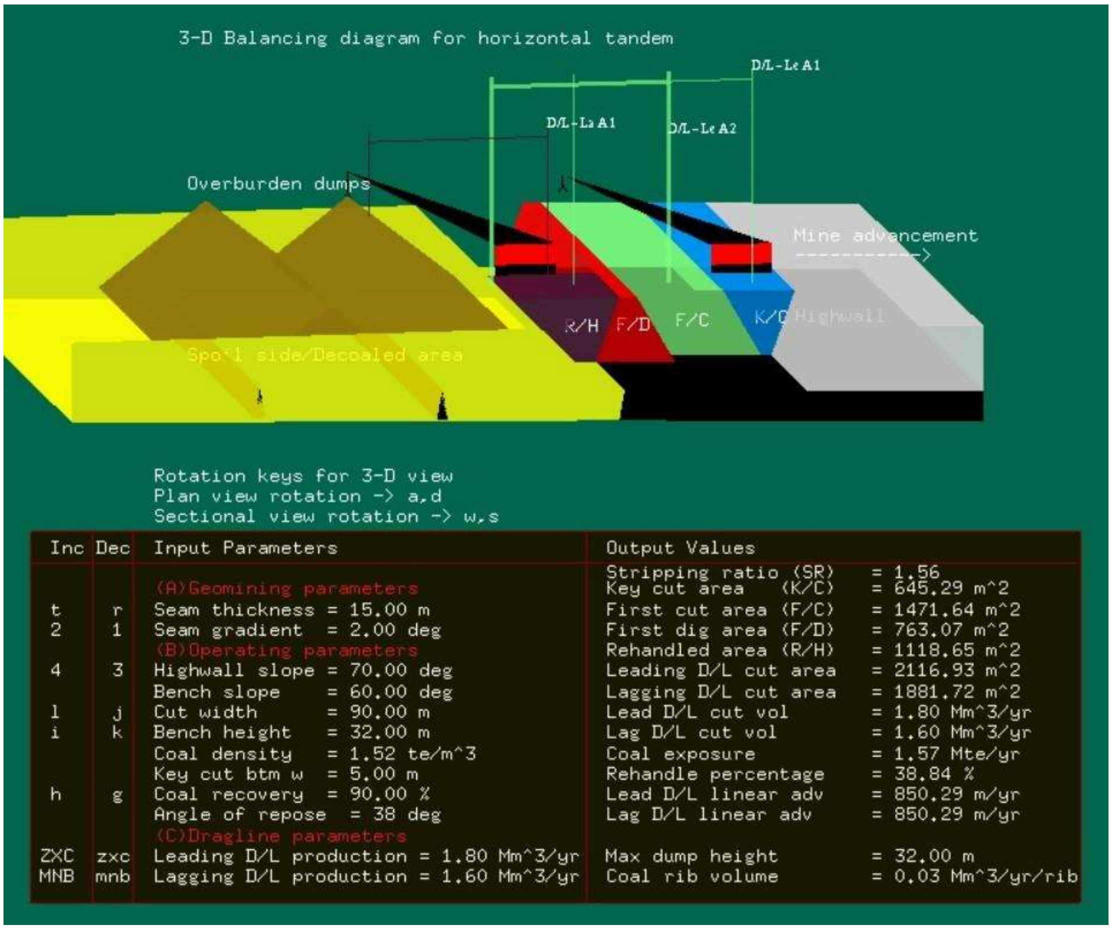

Figure 6.3.1: Three-dimensional balancing diagram for 1.80 Mm^3 leading and 1.60 Mm^3 lagging dragline

Table 6.3.1: Performance in horizontal tandem when annual production of leading dragline is more than lagging dragline.

Sl No.	Leading dragline (Mm^3/ year)	Lagging dragline (Mm^3/ year)	Key cut Area (K/C) (m^2)	First cut Area (F/C) (m^2)	First dig Area (F/D) (m^2)	Rehandled Area (R/H) (m^2)	Coal exposure (Mte/ year)	% Rehandle	Linear advancement Of Leading/ Lagging dragline (m/year)
1	1.80	1.60	645.29	1471.64	763.07	1118.65	1.57	38.84	850.29
2	2.20	2.00	645.29	1449.24	785.47	1118.65	1.94	38.84	1050.36
3	2.60	2.40	645.29	1434.00	800.70	1118.65	2.31	38.84	1250.42
4	3.00	2.80	645.29	1422.97	811.73	1118.65	2.68	38.84	1450.49
5	3.40	3.20	645.29	1414.61	820.09	1118.65	3.05	38.84	1650.56
6	3.80	3.60	645.29	1408.07	826.64	1118.65	3.42	38.84	1850.63
7	4.20	4.00	645.29	1402.79	831.91	1118.65	3.79	38.84	2050.69
8	4.60	4.40	645.29	1398.46	836.25	1118.65	4.16	38.84	2250.76

Table 6.3.2: Performance in vertical tandem mode-1when annual production of leading dragline is more than lagging dragline.

Sl No.	Leading dragline (Mm^3/ year)	Lagging dragline (Mm^3/ year)	Top cut area (T/C) (m^2)	Key cut area (K/C) (m^2)	First dig area (F/D) (m^2)	Rehandled area (R/H) (m^2)	Coal exposure (Mte/ year)	% Rehandle	Linear advancement of leading/ lagging dragline (m/year)	Upper bench + lower bench (m)
1	1.80	1.60	1521.19	183.52	1175.29	339.99	1.95	11.81	1055.90	16.90 +15.10
2	2.20	2.00	1502.80	187.48	1189.71	346.90	2.40	12.05	1301.56	16.70 +15.30
3	2.60	2.40	1490.26	190.21	1199.53	351.65	2.86	12.21	1547.19	16.56 +15.44
4	3.00	2.80	1481.14	192.21	1206.66	355.13	3.31	12.33	1792.82	16.46 +15.54
5	3.40	3.20	1474.22	193.72	1212.05	357.77	3.76	12.42	2038.43	16.38 +15.62
6	3.80	3.60	1468.79	194.92	1216.29	359.85	4.22	12.49	2284.05	16.32 +15.68
7	4.20	4.00	1464.41	195.89	1219.70	361.54	4.67	12.55	2529.66	16.27 +15.73

8	4.60	4.40	1460.81	196.68	1222.50	362.92	5.13	12.60	2775.26	16.23 +15.77

Table 6.3.3: Performance in vertical tandem mode-2 when annual production of leading dragline is more than lagging dragline.

Sl No.	Leading dragline (Mm^3/ year)	Lagging dragline (Mm^3/ year)	Top cut area (T/C) (m^2)	Key cut area (K/C) (m^2)	First dig area (F/D) (m^2)	Rehandled area (R/H) (m^2)	Coal exposure (Mte/ year)	% Rehandle	Linear advancement of leading/ lagging dragline (m/year)	Upper bench + lower bench (m)
1	1.80	1.60	1675.31	151.84	1052.85	284.47	1.98	9.88	1074.43	18.61 +13.39
2	2.20	2.00	1660.31	154.80	1064.89	289.68	2.45	10.06	1325.05	18.45 +13.55
3	2.60	2.40	1650.10	156.83	1073.07	293.25	2.91	10.18	1575.66	18.33 +13.67
4	3.00	2.80	1642.69	158.31	1079.00	295.86	3.37	10.27	1826.27	18.25 +13.75

5	3.40	3.20	1637.08	159.44	1083.49	297.84	3.84	10.34	2076.87	18.19 +13.81
6	3.80	3.60	1632.67	160.33	1087.01	299.39	4.30	10.40	2327.48	18.14 +13.86
7	4.20	4.00	1629.12	161.04	1089.84	300.65	4.76	10.44	2578.08	18.10 +13.90
8	4.60	4.40	1626.20	161.63	1092.17	301.69	5.22	10.48	2828.68	18.07 +13.93

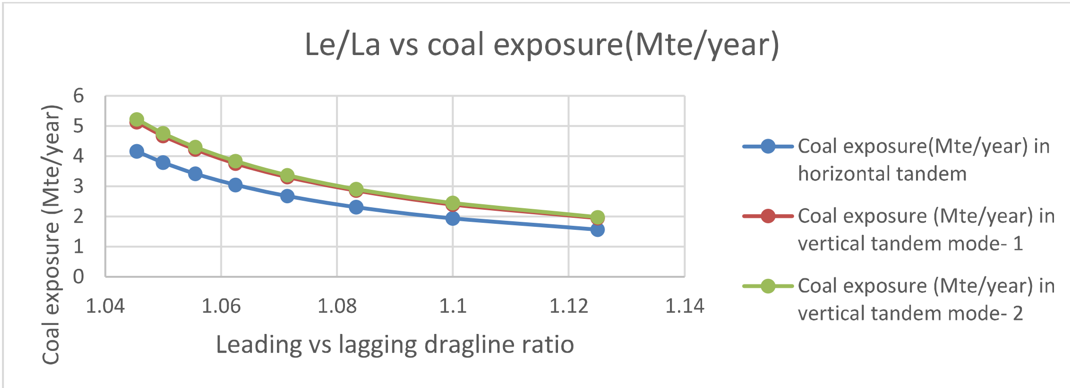

Figure 6.7: Le/La vs rate of coal exposure (Mte/year) in all three modes of tandem dragline operation.

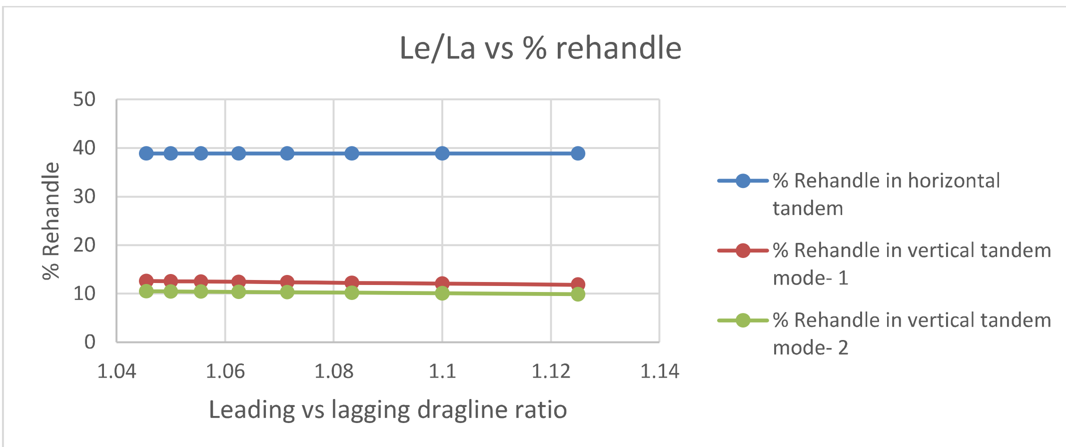

Figure 6.8: Le/La vs % rehandle in all three modes of tandem dragline operation.

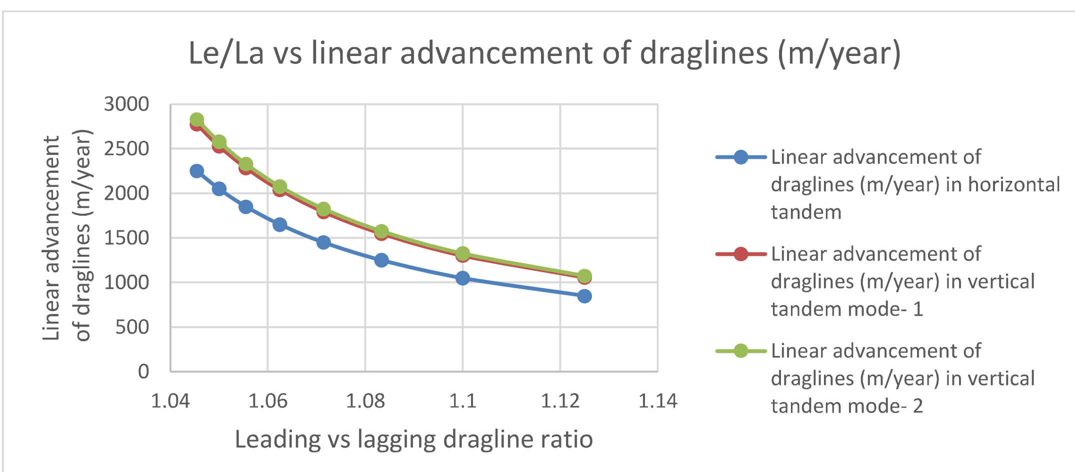

Figure 6.9: Le/La vs linear advancement of draglines (m/year) in all three modes of tandem dragline operation.

6.4 Relationship equations

Bench slope angle (60°), high wall angle (70°), angle of repose (38°), coal seam gradient (2°), coal seam thickness (15 m), density of coal (1.52 te/m^3), coal recovery (90%), cut width (90 m), bench height (32 m) and utilization have been kept constant.A parametric analysis was done to create equations that would correlate the rate of coal exposure and the percentage of rehandling with leading or lagging dragline capacities.

Case 1 Annual production of leading dragline is constant and annual production of lagging dragline is increasing

In first case, the annual production capacity of the leading dragline was set at 3.20 Mm^3, while the annual production capacity of the lagging dragline was varied from 1.60 to 4.80 Mm^3 in seventeen increments for the first case. The results have been given in table 6.4.1 for horizontal tandem, table 6.4.2 for vertical tandem mode-1, and table 6.4.3 for vertical tandem mode-2 for each variation in terms of coal exposure, percentage rehandle and linear advancement of the draglines. A typical three-dimensional balancing diagram is illustrated in figure 6.4.1, and the other diagrams are available in the Appendix 3 (figures 6.4.2 to 6.4.6). For all three modes of tandem dragline operation, a summary of important parameters like rate of coal exposure, percentage rehandle, and linear advancement of dragline per year are graphically represented in figure 6.10, 6.11 and 6.12.

The relationship equations are shown on the above-mentioned figures. By observing the equations, it is clear that rate of coal exposure, percentage of rehandling and advancement of draglines are highly correlated to the annual production capacity of the lagging dragline.

Case 2 Annual production of leading dragline is increasing, and annual production of lagging dragline is constant

In second case, the annual production capacity of the leading dragline was varied from 1.60 to 4.80 Mm^3 in seventeen increments, while the annual production capacity of the lagging dragline was set at 3.20 Mm^3. The results have been given in table 6.4.4 for horizontal tandem, table 6.4.5 for vertical tandem mode-1, and table 6.4.6 for vertical tandem mode-2 for each variation in terms of coal exposure, percentage rehandle and linear advancement of the draglines. 3-dimensional balancing diagrams are illustrated in appendix 3 (figures 6.4.7 to 6.4.12). For all three modes of tandem dragline operation, a summary of important parameters like rate of coal exposure, percentage rehandle, and linear advancement of dragline per year are graphically represented in figure 6.13, 6.14 and 6.15.

The relationship equations are shown on the above-mentioned figures. By observing the equations, it is clear that rate of coal exposure, percentage of rehandling and advancement of draglines are highly correlated to the annual production capacity of the lagging dragline.

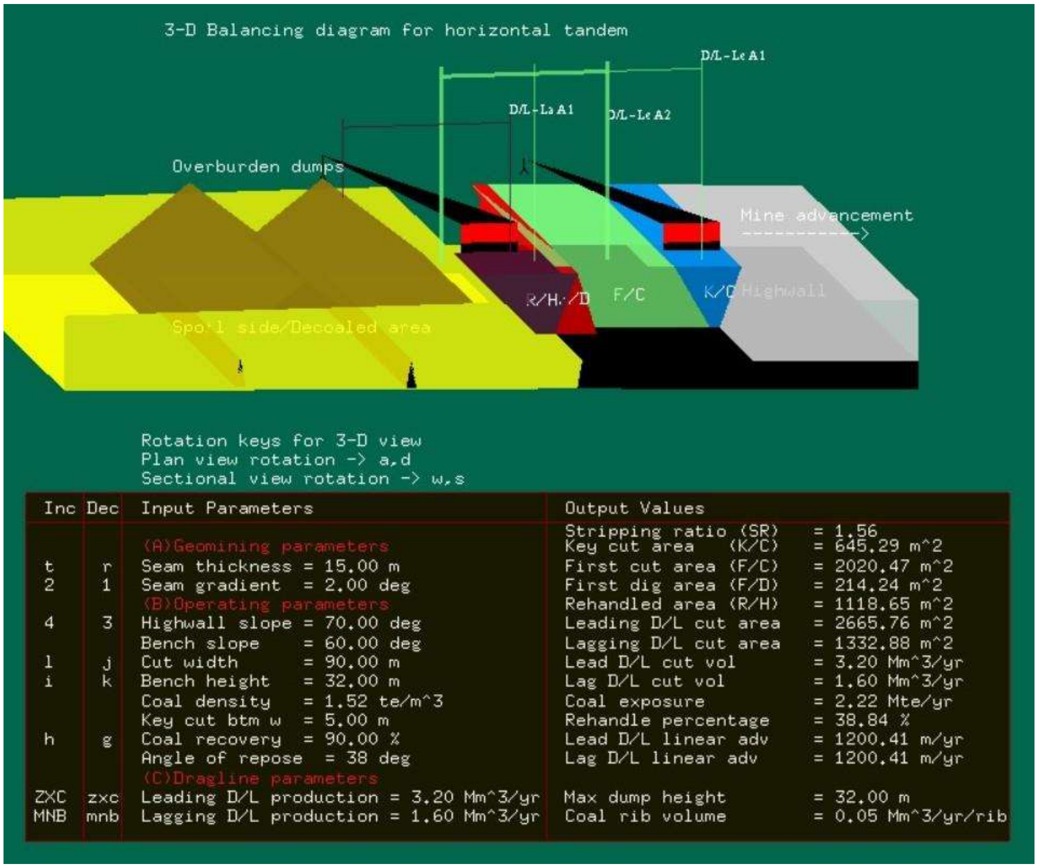

Figure 6.4.1: Three -dimensional balancing diagram for 3.20 Mm^3 leading and 1.60 Mm^3 lagging dragline

Table 6.4.1: Performance in horizontal tandem when annual production of leading dragline is constant and annual production of lagging dragline vary.

Sl No.	Leading dragline (Mm^3/ year)	Lagging dragline (Mm^3/ year)	Key cut Area (K/C) (m^2)	First cut Area (F/C) (m^2)	First dig Area (F/D) (m^2)	Rehandled Area (R/H) (m^2)	Coal exposure (Mte/ year)	% Rehandle	Linear advancement Of Leading (m/year)
1	3.20	1.60	645.29	2020.47	214.24	1118.65	2.22	38.84	1200.41
2	3.20	1.80	645.29	1913.84	320.87	1118.65	2.31	38.84	1250.42
3	3.20	2.00	645.29	1815.41	419.29	1118.65	2.40	38.84	1300.44
4	3.20	2.20	645.29	1724.28	510.43	1118.65	2.49	38.84	1350.46
5	3.20	2.40	645.29	1639.65	595.06	1118.65	2.59	38.84	1400.47
6	3.20	2.60	645.29	1560.86	673.85	1118.65	2.68	38.84	1450.49
7	3.20	2.80	645.29	1487.32	747.39	1118.65	2.77	38.84	1500.51
8	3.20	3.00	645.29	1418.52	816.18	1118.65	2.86	38.84	1550.52
9	3.20	3.20	645.29	1354.03	880.68	1118.65	2.96	38.84	1600.54
10	3.20	3.40	645.29	1293.44	941.26	1118.65	3.05	38.84	1650.56

11	3.20	3.60	645.29	1236.42	998.28	1118.65	3.14	38.84	1700.58
12	3.20	3.80	645.29	1182.66	1052.05	1118.65	3.23	38.84	1750.59
13	3.20	4.00	645.29	1131.88	1102.82	1118.65	3.33	38.84	1800.61
14	3.20	4.20	645.29	1083.85	1150.86	1118.65	3.42	38.84	1850.63
15	3.20	4.40	645.29	1038.35	1196.36	1118.65	3.51	38.84	1900.64
16	3.20	4.60	645.29	995.18	1239.53	1118.65	3.60	38.84	1950.66
17	3.20	4.80	645.29	954.17	1280.54	1118.65	3.69	38.84	2000.68

Table 6.4.2: Performance in vertical tandem mode-1 when annual production of leading dragline is constant and annual production of lagging dragline vary.

Sl No.	Leading dragline (Mm^3/ year)	Lagging dragline (Mm^3/ year)	Top cut area (T/C) (m^2)	Key cut area (K/C) (m^2)	First dig area (F/D) (m^2)	Rehandled area (R/H) (m^2)	Coal exposure (Mte/ year)	% Rehandle	Linear advancement of leading (m/year)	Upper bench + lower bench (m)
1	3.20	1.60	1948.63	102.50	828.88	196.68	2.88	6.83	1560.12	21.65 +10.35
2	3.20	1.80	1868.59	116.04	895.37	220.97	2.98	7.67	1612.39	20.76 +11.24

3	3.20	2.00	1793.55	129.42	957.03	244.81	3.07	8.50	1664.10	19.93 +12.07
4	3.20	2.20	1722.98	142.60	1014.42	268.17	3.17	9.31	1715.28	19.14 +12.86
5	3.20	2.40	1656.45	155.57	1067.98	291.03	3.26	10.11	1765.99	18.41 +13.59
6	3.20	2.60	1593.57	168.29	1118.13	313.37	3.35	10.88	1816.26	17.71 +14.29
7	3.20	2.80	1534.00	180.78	1165.22	335.21	3.45	11.64	1866.13	17.04 +14.96
8	3.20	3.00	1477.46	193.01	1209.53	356.53	3.54	12.38	1915.63	16.42 +15.58
9	3.20	3.20	1423.69	204.99	1251.32	377.35	3.63	13.10	1964.78	15.82 +16.18
10	3.20	3.40	1372.46	216.72	1290.82	397.68	3.72	13.81	2013.61	15.25 +16.75
11	3.20	3.60	1323.58	228.20	1328.22	417.53	3.81	14.50	2062.15	14.71 +17.29
12	3.20	3.80	1276.87	239.43	1363.70	436.90	3.90	15.17	2110.40	14.19 +17.81
13	3.20	4.00	1232.16	250.42	1397.42	455.81	3.99	15.83	2158.40	13.69 +18.31
14	3.20	4.20	1189.33	261.16	1429.50	474.27	4.07	16.47	2206.14	13.21 +18.79
15	3.20	4.40	1148.25	271.67	1460.08	492.29	4.16	17.09	2253.65	12.76 +19.24
16	3.20	4.60	1108.77	281.96	1489.27	509.90	4.25	17.70	2300.95	12.32

										+19.68
17	3.20	4.80	1070.83	292.01	1517.16	527.09	4.34	18.30	2348.03	11.90 +20.10

Table 6.4.3: Performance in vertical tandem mode-2 when annual production of leading dragline is constant and annual production of lagging dragline vary.

Sl No.	Leading dragline (Mm^3/ year)	Lagging dragline (Mm^3/ year)	Top cut area (T/C) (m^2)	Key cut area (K/C) (m^2)	First dig area (F/D) (m^2)	Rehandled area (R/H) (m^2)	Coal exposure (Mte/ year)	% Rehandle	Linear advancement of leading/ lagging dragline (m/year)	Upper bench + lower bench (m)
1	3.20	1.60	2034.60	88.78	756.62	171.88	2.90	5.97	1572.79	22.61 +9.39
2	3.20	1.80	1965.83	99.68	814.48	191.61	3.01	6.65	1627.81	21.84 +10.16
3	3.20	2.00	1901.97	110.30	867.73	210.70	3.11	7.32	1682.46	21.13 +10.87
4	3.20	2.20	1842.46	120.62	916.91	229.16	3.21	7.96	1736.80	20.47 +11.53

5	3.20	2.40	1786.86	130.65	962.50	246.99	3.31	8.58	1790.85	19.85 +12.15
6	3.20	2.60	1734.74	140.37	1004.89	264.22	3.41	9.17	1844.66	19.27 +12.73
7	3.20	2.80	1685.80	149.76	1044.42	280.85	3.51	9.75	1898.21	18.73 +13.27
8	3.20	3.00	1639.70	158.91	1081.39	296.91	3.60	10.31	1951.58	18.22 +13.78
9	3.20	3.20	1596.21	167.75	1116.04	312.42	3.70	10.85	2004.74	17.74 +14.26
10	3.20	3.40	1555.11	176.31	1148.58	327.40	3.80	11.37	2057.73	17.28 +14.72
11	3.20	3.60	1516.18	184.59	1179.23	341.87	3.90	11.87	2110.57	16.85 +15.15
12	3.20	3.80	1479.25	192.62	1208.13	355.85	4.00	12.36	2163.25	16.44 +15.56
13	3.20	4.00	1444.17	200.39	1235.44	369.36	4.09	12.83	2215.81	16.05 +15.95
14	3.20	4.20	1410.79	207.92	1261.29	382.43	4.19	13.28	2268.23	15.68 +16.32
15	3.20	4.40	1378.98	215.21	1285.80	395.07	4.29	13.72	2320.55	15.32

										+16.68
16	3.20	4.60	1348.64	222.28	1309.08	407.30	4.38	14.14	2372.75	14.98 +17.02
17	3.20	4.80	1319.66	229.13	1331.21	419.14	4.48	14.55	2424.87	14.66 +17.34

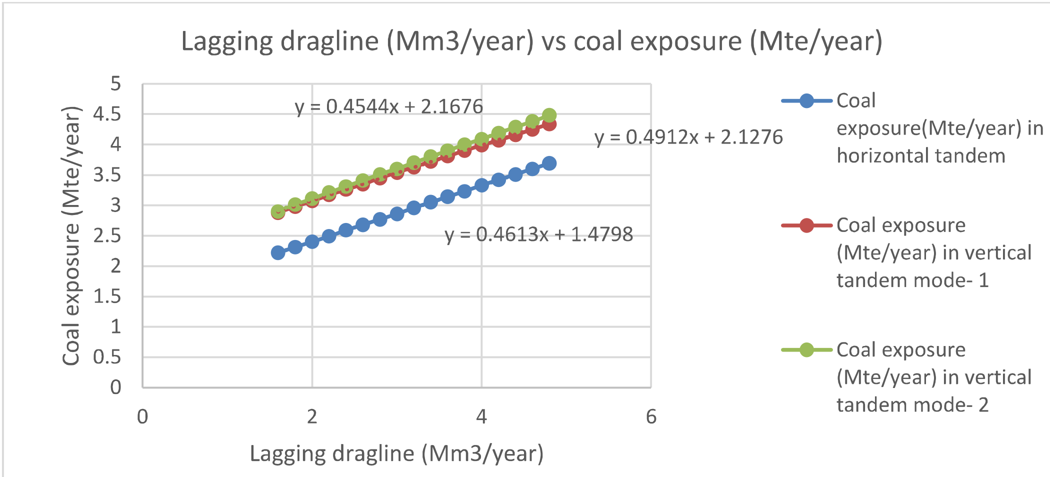

Figure 6.10: Annual production of lagging dragline vs rate of coal exposure (Mte/year) in all three modes of tandem dragline operation.

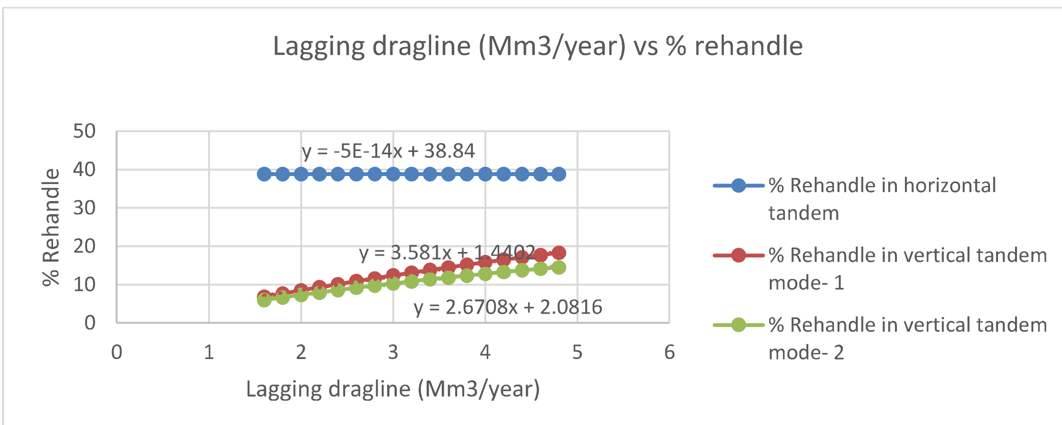

Figure 6.11: Annual production of lagging dragline vs % rehandle in all three modes of tandem dragline operation.

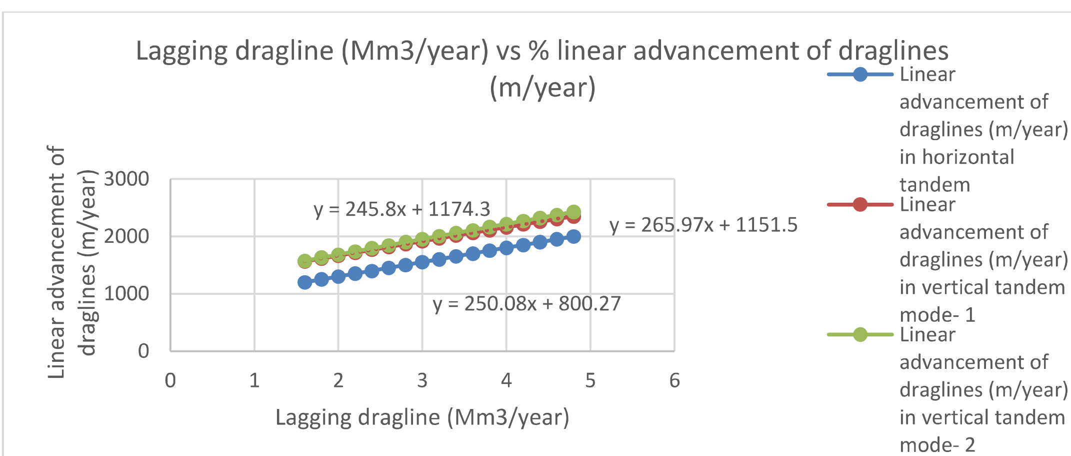

Figure 6.12: Annual production of lagging dragline vs linear advancement of draglines (m/year) in all three modes of tandem dragline operation.

Table 6.4.4: Performance in horizontal tandem when annual production of leading dragline is constant and annual production of lagging dragline vary.

Sl No.	Leading dragline (Mm^3/ year)	Lagging dragline (Mm^3/ year)	Key cut Area (K/C) (m^2)	First cut Area (F/C) (m^2)	First dig Area (F/D) (m^2)	Rehandled Area (R/H) (m^2)	Coal exposure (Mte/ year)	% Rehandle	Linear advancement Of Leading/ Lagging dragline (m/year)
1	1.60	3.20	645.29	687.59	1547.12	1118.65	2.22	38.84	1200.41
2	1.80	3.20	645.29	794.22	1440.49	1118.65	2.31	38.84	1250.42
3	2.00	3.20	645.29	892.65	1342.06	1118.65	2.40	38.84	1300.44
4	2.20	3.20	645.29	983.79	1250.92	1118.65	2.49	38.84	1350.46
5	2.40	3.20	645.29	1068.41	1166.29	1118.65	2.59	38.84	1400.47
6	2.60	3.20	645.29	1147.20	1087.50	1118.65	2.68	38.84	1450.49
7	2.80	3.20	645.29	1220.74	1013.96	1118.65	2.77	38.84	1500.51
8	3.00	3.20	645.29	1289.54	945.17	1118.65	2.86	38.84	1550.52
9	3.20	3.20	645.29	1354.03	880.68	1118.65	2.96	38.84	1600.54
10	3.40	3.20	645.29	1414.62	820.09	1118.65	3.05	38.84	1650.56
11	3.60	3.20	645.29	1471.64	763.07	1118.65	3.14	38.84	1700.57
12	3.80	3.20	645.29	1525.40	709.31	1118.65	3.23	38.84	1750.59
13	4.00	3.20	645.29	1576.18	658.53	1118.65	3.33	38.84	1800.61

14	4.20	3.20	645.29	1624.21	610.50	1118.65	3.42	38.84	1850.63
15	4.40	3.20	645.29	1669.71	564.99	1118.65	3.51	38.84	1900.64
16	4.60	3.20	645.29	1712.88	521.82	1118.65	3.60	38.84	1950.66
17	4.80	3.20	645.29	1753.89	480.81	1118.65	3.69	38.84	2000.68

Table 6.4.5: Performance in vertical tandem mode-1 when annual production of leading dragline is constant and annual production of lagging dragline vary.

Sl No.	Leading dragline (Mm^3/ year)	Lagging dragline (Mm^3/ year)	Top cut area (T/C) (m^2)	Key cut area (K/C) (m^2)	First dig area (F/D) (m^2)	Rehandled area (R/H) (m^2)	Coal exposure (Mte/ year)	% Rehandle	Linear advancement of leading/ lagging dragline (m/year)	Upper bench + lower bench (m)
1	1.60	3.20	812.03	365.10	1702.87	651.38	2.51	22.62	1359.24	9.02 +22.98
2	1.80	3.20	918.25	334.15	1627.60	598.89	2.65	20.79	1437.24	10.20 +21.80
3	2.00	3.20	1013.04	307.65	1559.31	553.79	2.80	19.23	1514.36	11.26 +20.74
4	2.20	3.20	1098.28	284.72	1497.00	514.63	2.94	17.87	1590.75	12.20

										+19.80
5	2.40	3.20	1175.45	264.69	1439.85	480.32	3.08	16.68	1666.50	13.06 +18.94
6	2.60	3.20	1245.71	247.06	1387.22	450.04	3.22	15.63	1741.72	13.84 +18.16
7	2.80	3.20	1310.02	231.44	1338.55	423.11	3.35	14.69	1816.47	14.56 +17.44
8	3.00	3.20	1369.13	217.50	1293.37	399.02	3.49	13.85	1890.80	15.21 +16.79
9	3.20	3.20	1423.69	204.99	1251.32	377.35	3.63	13.10	1964.78	15.82 +16.18
10	3.40	3.20	1474.22	193.72	1212.05	357.77	3.76	12.42	2038.43	16.38 +15.62
11	3.60	3.20	1521.19	183.52	1175.29	339.99	3.90	11.81	2111.80	16.90 +15.10
12	3.80	3.20	1564.96	174.24	1140.80	323.78	4.04	11.24	2184.91	17.39 +14.61
13	4.00	3.20	1605.88	165.77	1108.36	308.94	4.17	10.73	2257.79	17.84 +14.16
14	4.20	3.20	1644.20	158.01	1077.79	295.32	4.30	10.25	2330.47	18.27 +13.73

15	4.40	3.20	1680.21	150.88	1048.91	282.77	4.44	9.82	2402.94	18.67 +13.33
16	4.60	3.20	1714.09	144.31	1021.61	271.18	4.57	9.42	2475.26	19.05 +12.95
17	4.80	3.20	1746.03	138.23	995.73	260.44	4.70	9.04	2547.41	19.40 +12.60

Table 6.4.6: Performance in vertical tandem mode-2 when annual production of leading dragline is constant and annual production of lagging dragline vary.

Sl No.	Leading dragline (Mm^3/ year)	Lagging dragline (Mm^3/ year)	Top cut area (T/C) (m^2)	Key cut area (K/C) (m^2)	First dig area (F/D) (m^2)	Rehandled area (R/H) (m^2)	Coal exposure (Mte/ year)	% Rehandle	Linear advancement of leading/ lagging dragline (m/year)	Upper bench + lower bench (m)
1	1.60	3.20	1127.22	277.13	1475.65	501.64	2.62	17.42	1419.43	12.52 +19.48
2	1.80	3.20	1205.08	257.19	1417.73	467.44	2.76	16.23	1493.68	13.39 +18.61
3	2.00	3.20	1275.89	239.67	1364.44	437.30	2.89	15.18	1567.53	14.18

										+17.82
4	2.20	3.20	1340.61	224.17	1315.22	410.56	3.03	14.26	1641.04	14.90 +17.10
5	2.40	3.20	1400.02	210.38	1269.61	386.69	3.17	13.43	1714.27	15.56 +16.44
6	2.60	3.20	1454.78	198.03	1227.20	365.25	3.30	12.68	1787.22	16.16 +15.84
7	2.80	3.20	1505.43	186.91	1187.65	345.91	3.43	12.01	1859.93	16.73 +15.27
8	3.00	3.20	1552.45	176.87	1150.68	328.38	3.57	11.40	1932.43	17.25 +14.75
9	3.20	3.20	1596.21	167.75	1116.04	312.42	3.70	10.85	2004.74	17.74 +14.26
10	3.40	3.20	1637.08	159.44	1083.49	297.84	3.84	10.34	2076.87	18.19 +13.81
11	3.60	3.20	1675.31	151.84	1052.85	284.47	3.97	9.88	2148.85	18.61 +13.39
12	3.80	3.20	1711.18	144.86	1023.95	272.17	4.10	9.45	2220.68	19.01 +12.99
13	4.00	3.20	1744.91	138.45	996.65	260.82	4.23	9.06	2292.39	19.39 +12.61

14	4.20	3.20	1776.68	132.52	970.80	250.32	4.37	8.69	2363.97	19.74 +12.26
15	4.40	3.20	1806.66	127.04	946.31	240.57	4.50	8.35	2435.43	20.07 +11.93
16	4.60	3.20	1835.00	121.95	923.05	231.52	4.63	8.04	2506.81	20.39 +11.61
17	4.80	3.20	1861.85	117.22	900.93	223.07	4.76	7.75	2578.08	20.69 +11.31

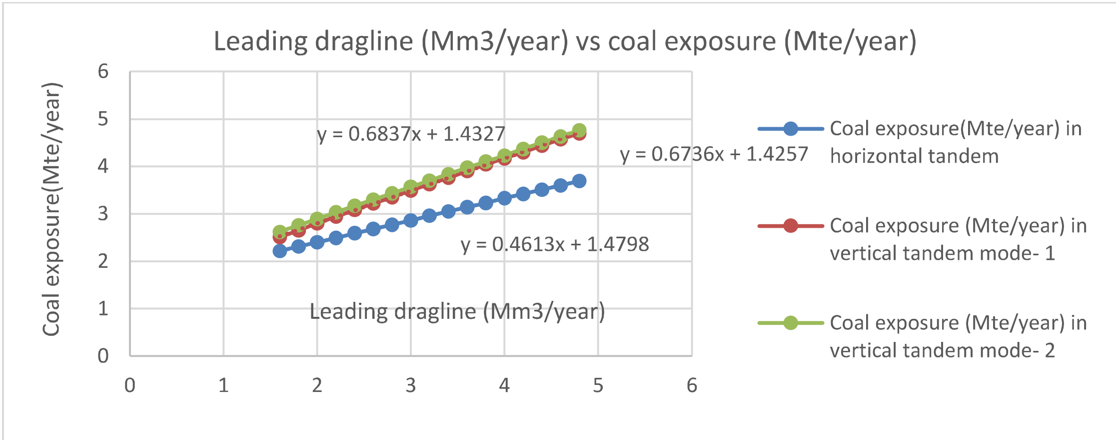

Figure 6.13: Annual production of leading dragline vs rate of coal exposure (Mte/year) in all three modes of tandem dragline operation.

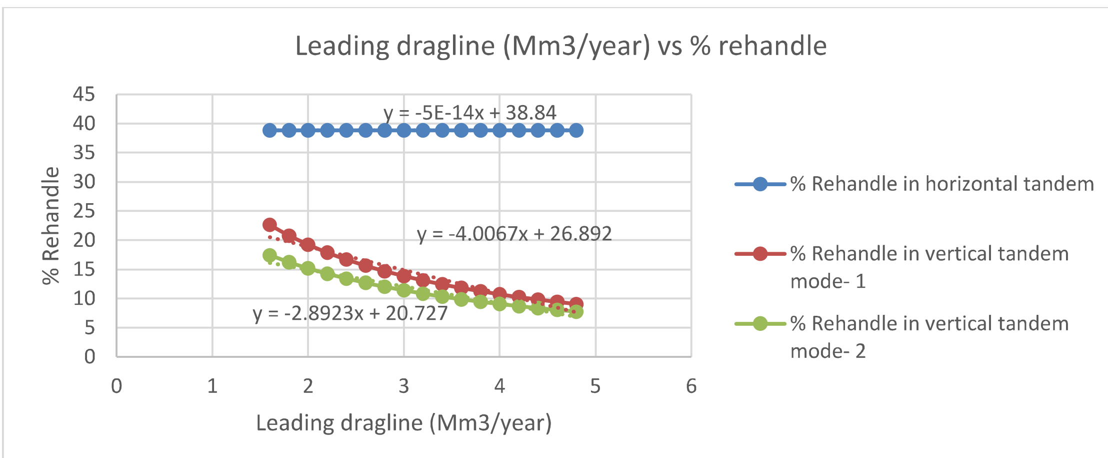

Figure 6.14: Annual production of leading dragline vs % rehandle in all three modes of tandem dragline operation.

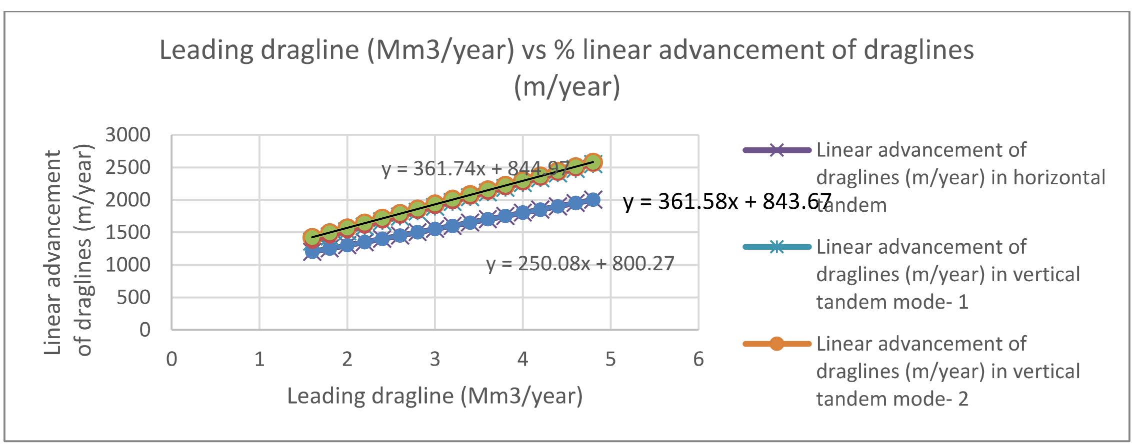

Figure 6.15: Annual production of leading dragline vs linear advancement of draglines (m/year) in all three modes of tandem dragline operation.

6.5 Influence of cut width

This study analyses the effect of cut width, which was varied from 55 m to 110 m in intervals of 5 m, while retaining all other relevant parameters. The results have been given in table 6.5.1 for horizontal tandem, table 6.5.2 for vertical tandem mode-1, and table 6.5.3 for vertical tandem mode-2 for each variation in terms of coal exposure, percentage rehandle and linear advancement of the draglines. A typical three-dimensional balancing diagram is illustrated in figure 6.5.1, and the other diagrams are available in the Appendix 3 (figures 6.5.2 to 6.5.6).

For all three modes of tandem dragline operation, a summary of important parameters like rate of coal exposure, percentage rehandle, and linear advancement of dragline per year with variation in cut width are graphically represented in figure 6.16, 6.17 and 6.18. From these figures and table, following conclusions can be drawn.

(i) In all three modes of tandem operations, as the cut width increases, the rehandle percentage decreases due to a constant rehandle area for the same bench height and does not vary by varying cut width. However, the percentage of rehandle varies depending on the total volume of excavation which changes with the width. This is only true if the dragline can reach far enough to dump the material beyond the exposed coal bench. If the cut width is too wide and the dragline reach is limited, then the excavated material may be placed on the coal bench, which would result in a greater rehandle percentage.

(ii) As the cut width is increased, the coal exposure per year will also rise assuming the leading dragline has sufficient reach to dump the material beyond the coal bench. A wider cut width might still be achievable by relocating the leading dragline away from the high wall, but this will come at the cost of efficiency as the swing angle has increased and may result in a decrease in coal exposure per year.

(iii) As cut width increases, the rate of advance of draglines slows down as the cross-sectional area of the overburden grows while the dragline's yearly productivity remains constant. On the other hand, the rate of uncovering coal increases since the increase in cut width more than offsets the decrease due to decrease in linear advancement.

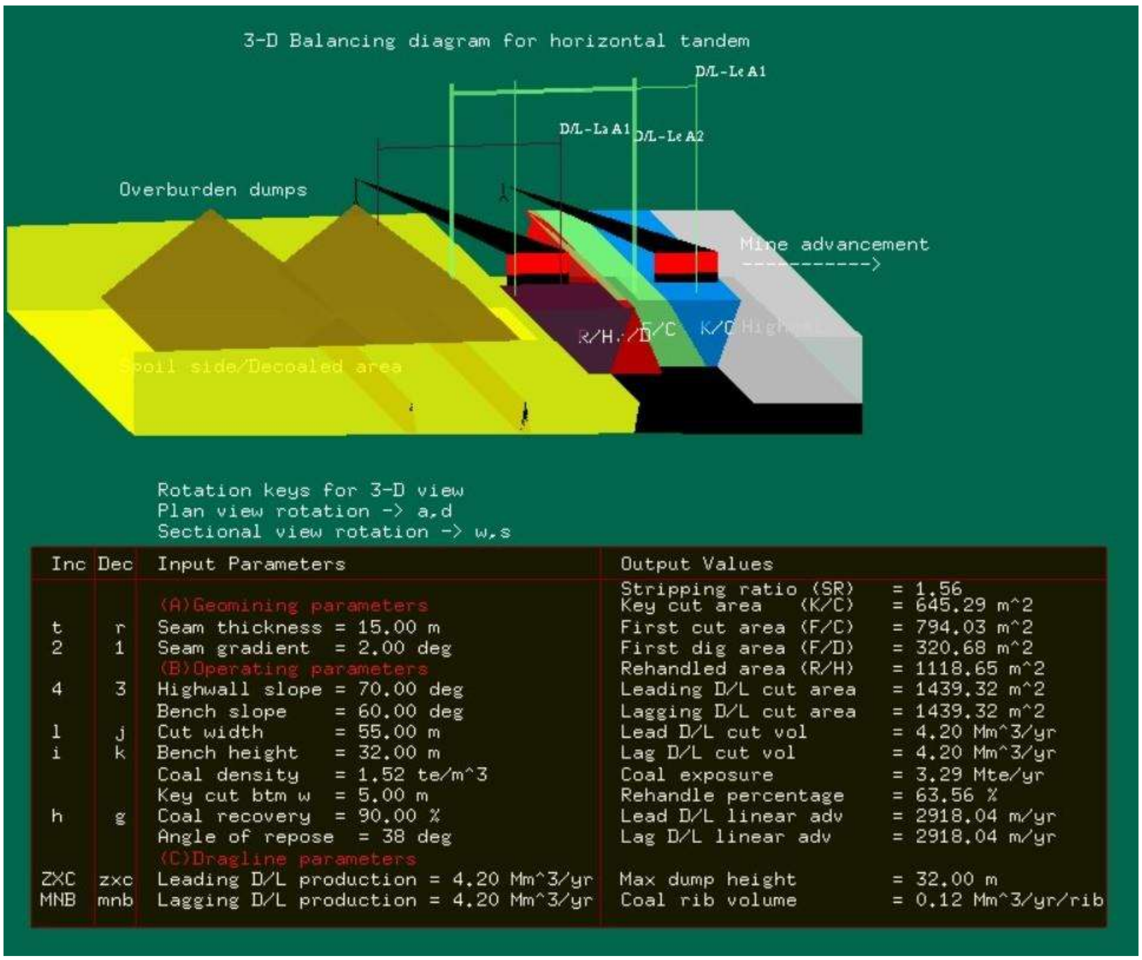

Figure 6.5.1: Three-dimensional balancing diagram for 55 m cut width

Table 6.5.1: Performance in horizontal tandem with variation of cut width.

Sl No.	Cut width (m)	Leading dragline (Mm^3/ year)	Lagging dragline (Mm^3/ year)	Key cut Area (K/C) (m^2)	First cut Area (F/C) (m^2)	First dig Area (F/D) (m^2)	Rehandled Area (R/H) (m^2)	Coal exposure (Mte/ year)	% Rehandle	Linear advancement Of Leading/ Lagging dragline (m/year)
1	55	4.20	4.20	645.29	794.03	320.68	1118.65	3.29	63.56	2918.04
2	60	4.20	4.20	645.29	874.03	400.68	1118.65	3.40	58.26	2764.39
3	65	4.20	4.20	645.29	954.03	480.68	1118.65	3.50	53.78	2626.11
4	70	4.20	4.20	645.29	1034.03	560.68	1118.65	3.59	49.94	2501.01
5	75	4.20	4.20	645.29	1114.03	640.68	1118.65	3.67	46.61	2387.28
6	80	4.20	4.20	645.29	1194.03	720.68	1118.65	3.75	43.70	2283.45
7	85	4.20	4.20	645.29	1274.03	800.68	1118.65	3.82	41.13	2188.27
8	90	4.20	4.20	645.29	1354.03	880.68	1118.65	3.88	38.84	2100.71
9	95	4.20	4.20	645.29	1434.03	960.68	1118.65	3.94	36.80	2019.89
10	100	4.20	4.20	645.29	1514.03	1040.68	1118.65	3.99	34.96	1945.052
11	105	4.20	4.20	645.29	1594.03	1120.68	1118.65	4.04	33.29	1875.57
12	110	4.20	4.20	645.29	1674.03	1200.68	1118.65	4.09	31.78	1810.87

Table 6.5.2: Performance in vertical tandem mode-1 with variation of cut width.

Sl No.	Cut width	Leading dragline (Mm^3/ year)	Lagging dragline (Mm^3/ year)	Top cut area (T/C) (m^2)	Key cut area (K/C) (m^2)	First dig area (F/D) (m^2)	Rehandled area (R/H) (m^2)	Coal exposure (Mte/ year)	% Rehandle	Linear advancement of leading/ lagging dragline (m/year)	Upper bench + lower bench (m)
1	55	4.20	4.20	863.36	207.47	689.17	381.65	4.43	21.68	3922.20	15.70 +16.30
2	60	4.20	4.20	943.43	206.93	769.64	380.71	4.50	19.83	3651.03	15.72 +16.28
3	65	4.20	4.20	1023.49	206.48	850.04	379.93	4.55	18.27	3414.73	15.75 +16.25
4	70	4.20	4.20	1103.54	206.09	930.37	379.26	4.61	16.93	3207.00	15.76 +16.24
5	75	4.20	4.20	1183.59	205.76	1010.65	378.68	4.65	15.78	3023.00	15.78 +16.22
6	80	4.20	4.20	1263.62	205.47	1090.91	378.18	4.69	14.77	2858.91	15.80 +16.20
7	85	4.20	4.20	1343.66	205.22	1171.12	377.74	4.73	13.89	2711.64	15.81 +16.19

8	90	4.20	4.20	1423.69	204.99	1251.32	377.35	4.76	13.10	2578.77	15.82 +16.18
9	95	4.20	4.20	1503.71	204.79	1331.49	377.01	4.79	12.40	2458.28	15.83 +16.17
10	100	4.20	4.20	1583.74	204.61	1411.65	376.70	4.82	11.77	2348.53	15.84 +16.16
11	105	4.20	4.20	1663.76	204.45	1491.79	376.42	4.84	11.20	2248.14	15.85 +16.15
12	110	4.20	4.20	1743.78	204.31	1571.91	376.16	4.87	10.69	2155.96	15.85 +16.15

Table 6.5.3: Performance in vertical tandem mode-2 with variation of cut width.

Sl No.	Cut width	Leading dragline (Mm^3/ year)	Lagging dragline (Mm^3/ year)	Top cut area (T/C) (m^2)	Key cut area (K/C) (m^2)	First dig area (F/D) (m^2)	Rehandled area (R/H) (m^2)	Coal exposure (Mte/ year)	% Rehandle	Linear advancement of leading/ lagging dragline (m/year)	Upper bench + lower bench (m)
1	55	4.20	4.20	1022.58	152.23	585.19	285.16	4.64	16.20	4107.25	18.59 +13.41
2	60	4.20	4.20	1105.26	155.28	659.46	290.52	4.68	15.13	3800.00	18.42 +13.58
3	65	4.20	4.20	1187.63	157.97	734.40	295.25	4.72	14.19	3536.45	18.27 +13.73
4	70	4.20	4.20	1269.73	160.39	809.91	299.45	4.75	13.37	3307.80	18.14 +13.86
5	75	4.20	4.20	1351.61	162.50	885.90	303.21	4.78	12.63	3107.42	18.02 +13.98
6	80	4.20	4.20	1433.30	164.42	962.28	306.58	4.81	11.98	2930.30	17.92 +14.08
7	85	4.20	4.20	1514.82	166.17	1039.01	309.64	4.84	11.38	2772.60	17.82 +14.18

8	90	4.20	4.20	1596.21	167.75	1116.04	312.42	4.86	10.85	2631.23	17.74 +14.26
9	95	4.20	4.20	1677.48	169.20	1193.32	314.96	4.88	10.36	2503.75	17.66 +14.34
10	100	4.20	4.20	1758.64	170.53	1270.83	317.28	4.90	9.92	2388.21	17.59 +14.41
11	105	4.20	4.20	1839.72	171.75	1348.54	319.42	4.92	9.51	2282.96	17.52 +14.48
12	110	4.20	4.20	1920.70	172.87	1426.42	321.39	4.94	9.13	2186.70	17.46 +14.54

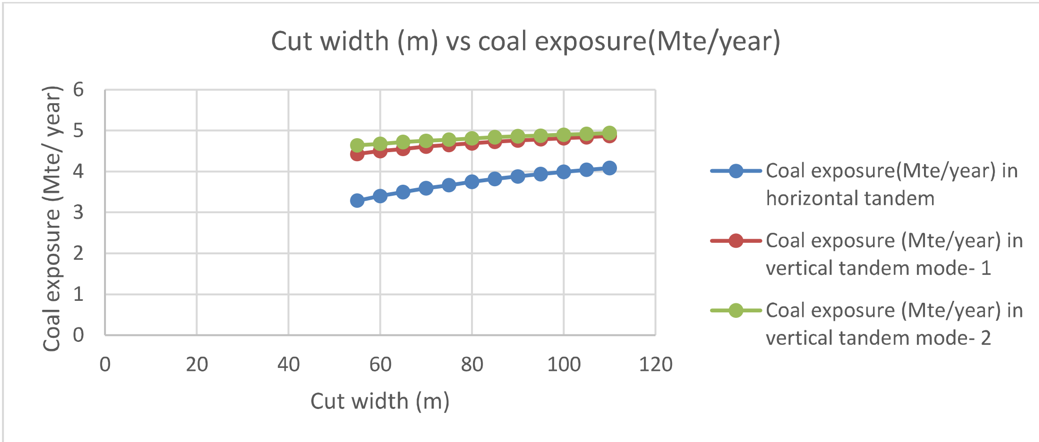

Figure 6.16: Cut width vs rate of coal exposure (Mte/year) in all three modes of tandem dragline operation.

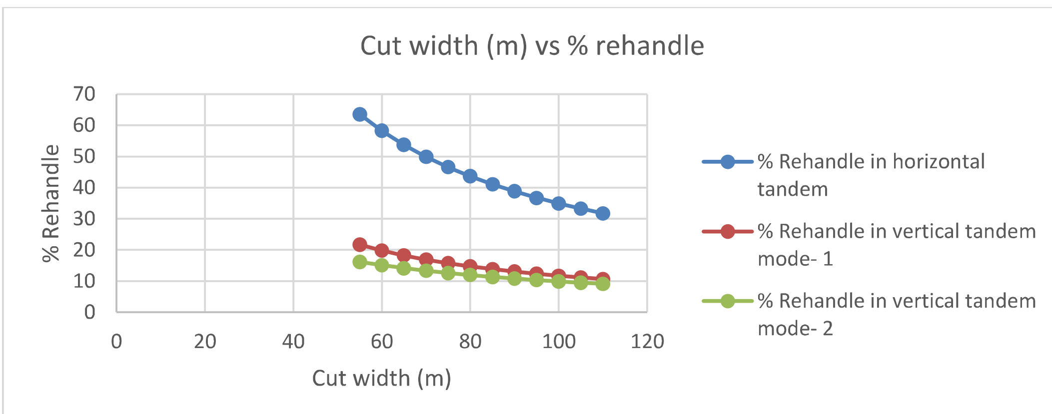

Figure 6.17: Cut width vs % rehandle in all three modes of tandem dragline operation.

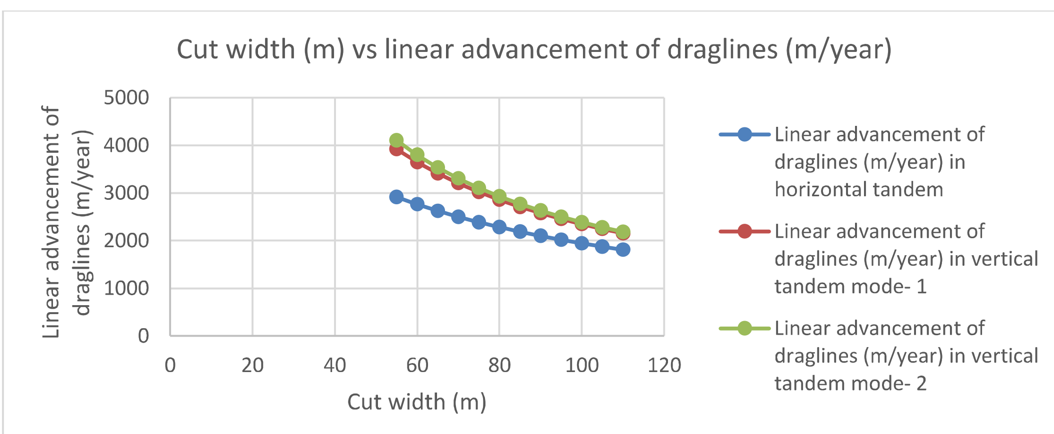

Figure 6.18: Cut width vs linear advancement of draglines (m/year) in all three modes of tandem dragline operation.

6.6 Influence of stripping bench height

This study analyses the effect of stripping bench height, which was varied from 28 m to 42 m in intervals of 2 m, while retaining all other relevant parameters. The results have been given in table 6.6.1 for horizontal tandem, table 6.6.2 for vertical tandem mode-1, and table 6.6.3 for vertical tandem mode-2 for each variation in terms of coal exposure, percentage rehandle and linear advancement of the draglines. A typical three-dimensional balancing diagram is illustrated in figure 6.6.1 and the other diagrams are available in the Appendix 3 (Figure 6.6.2 to 6.6.6).

For all three modes of tandem dragline operation, a summary of important parameters like rate of coal exposure, percentage rehandle, and linear advancement of dragline per year with variation in stripping bench height are graphically represented in figure 6.19, 6.20 and 6.21. From these figures and table, following conclusions can be drawn.

(i) As the height of the stripping bench (overburden thickness) increases, the percentage /proportion of rehandling increases due to a larger cross-sectional area of rehandling.

(ii) As the bench height increases, coal exposure drops. This is likely due to both the reduction in linear advancement of draglines caused by the increase in the cross-sectional area of the overburden, and the additional unproductive rehandling by the dragline.

(iii) Research shows that when the depth of a dragline bench exceeds 40 meters, the operator is unable to see the bucket properly, resulting in a floating tendency of the dragline bucket. This makes it difficult to fill the bucket correctly, decreasing production. In cases where the overburden thickness is greater, the angle of the bench slope should be flattened for stability. Shevyakov (1965) suggests that when the thickness is 50 meters, the angle should be around 50 degrees, which would increase the width of the key cut and the first cut width. The disruption of load distribution on the draglines would be significant in this case, which is why the draglines benches are usually limited to 40 m.

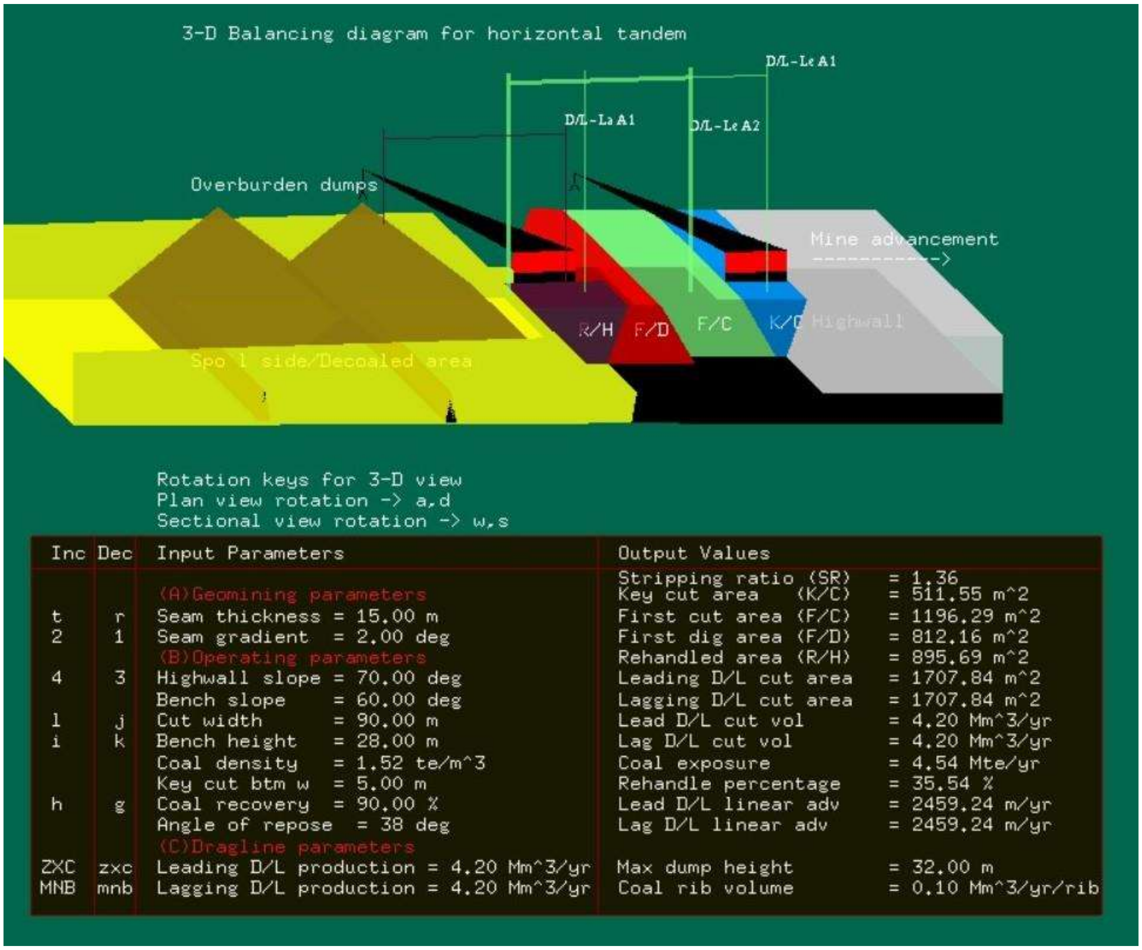

Figure 6.6.1: Three-dimensional balancing diagram for 28 m bench height

Table 6.6.1: Performance in horizontal tandem with variation of bench height.

Sl No.	Bench height (m)	Leading dragline (Mm^3/ year)	Lagging dragline (Mm^3/ year)	Key cut Area (K/C) (m^2)	First cut Area (F/C) (m^2)	First dig Area (F/D) (m^2)	Rehandled Area (R/H) (m^2)	Coal exposure (Mte/ year)	% Rehandle	Linear advancement Of Leading/ Lagging dragline (m/year)
1	28	4.20	4.20	511.55	1196.29	812.16	895.69	4.54	35.54	2459.24
2	30	4.20	4.20	576.53	1275.58	847.90	1004.21	4.19	37.19	2267.69
3	32	4.20	4.20	645.29	1354.03	880.68	1118.65	3.88	38.84	2100.70
4	34	4.20	4.20	717.85	1431.65	910.50	1239.00	3.61	40.49	1953.94
5	36	4.20	4.20	794.20	1508.44	937.36	1365.28	3.37	42.14	1823.99
6	38	4.20	4.20	874.34	1584.40	961.26	1497.47	3.15	43.79	1708.19
7	40	4.20	4.20	958.27	1659.52	982.21	1635.58	2.96	45.43	1604.41
8	42	4.20	4.20	1045.99	1733.81	1000.19	1779.62	2.79	47.08	1510.90

Table 6.6.2: Performance in vertical tandem mode-1 with variation of bench height.

Sl No.	Bench Height	Leading dragline (Mm^3/ year)	Lagging dragline (Mm^3/ year)	Top cut area (T/C) (m^2)	Key cut area (K/C) (m^2)	First dig area (F/D) (m^2)	Rehandled area (R/H) (m^2)	Coal exposure (Mte/ year)	% Rehandle	Linear advancement of leading/ lagging dragline (m/year)	Upper bench + lower bench (m)
1	28	4.20	4.20	1248.79	165.17	1106.04	307.90	5.49	12.22	2970.39	13.88 +14.12
2	30	4.20	4.20	1336.35	184.56	1179.09	341.80	5.10	12.66	2761.51	14.85 +15.15
3	32	4.20	4.20	1423.69	204.99	1251.32	377.35	4.76	13.10	2578.77	15.82 +16.18
4	34	4.20	4.20	1510.80	226.49	1322.71	414.57	4.46	13.55	2417.56	16.79 +17.21
5	36	4.20	4.20	1597.68	249.05	1393.27	453.45	4.20	14.00	2274.29	17.75 +18.25

6	38	4.20	4.20	1684.33	272.69	1462.98	494.03	3.96	14.45	2146.12	18.71 +19.29
7	40	4.20	4.20	1770.75	297.40	1531.85	536.30	3.75	14.90	2030.80	19.67 +20.33
8	42	4.20	4.20	1856.93	323.21	1599.86	580.28	3.56	15.35	1926.48	20.63 +21.37

Table 6.6.3: Performance in vertical tandem mode-2 with variation of bench height.

Sl No.	Bench Height	Leading dragline (Mm^3/ year)	Lagging dragline (Mm^3/ year)	Top cut area (T/C) (m^2)	Key cut area (K/C) (m^2)	First dig area (F/D) (m^2)	Rehandled area (R/H) (m^2)	Coal exposure (Mte/ year)	% Rehandle	Linear advancement of leading/ lagging dragline (m/year)	Upper bench + lower bench (m)
1	28	4.20	4.20	1389.63	137.56	992.81	259.25	5.58	10.29	3022.39	15.44 +12.56
2	30	4.20	4.20	1492.69	152.35	1054.95	285.37	5.20	10.57	2813.71	16.59 +13.41
3	32	4.20	4.20	1596.21	167.75	1116.04	312.42	4.86	10.85	2631.23	17.74

											+14.26
4	34	4.20	4.20	1700.19	183.73	1176.08	340.36	4.56	11.12	2470.31	18.89 +15.11
5	36	4.20	4.20	1804.60	200.29	1235.10	369.19	4.30	11.39	2327.38	20.05 +15.95
6	38	4.20	4.20	1909.45	217.42	1293.13	398.89	4.06	11.66	2199.58	21.22 +16.78
7	40	4.20	4.20	2014.73	235.11	1350.16	429.44	3.85	11.93	2084.65	22.39 +17.61
8	42	4.20	4.20	2120.42	253.34	1406.24	460.24	3.66	12.19	1980.74	23.56 +18.44

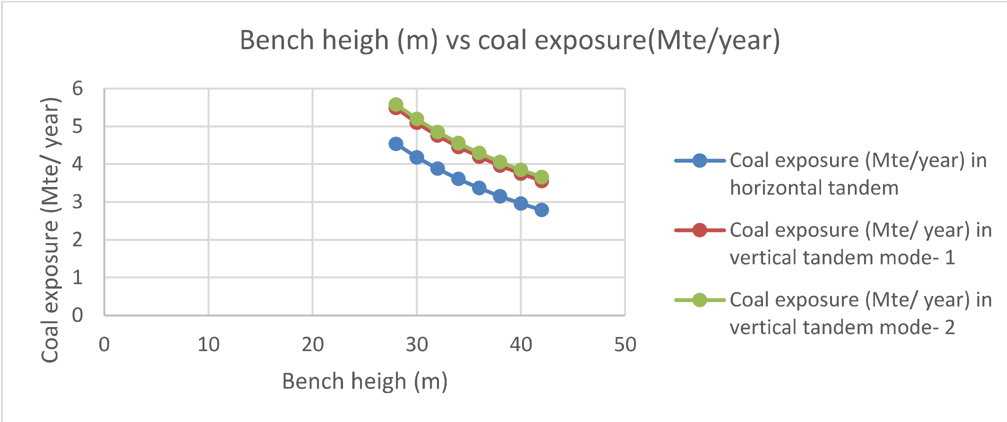

Figure 6.19: Bench height vs rate of coal exposure (Mte/year) in all three modes of tandem dragline operation.

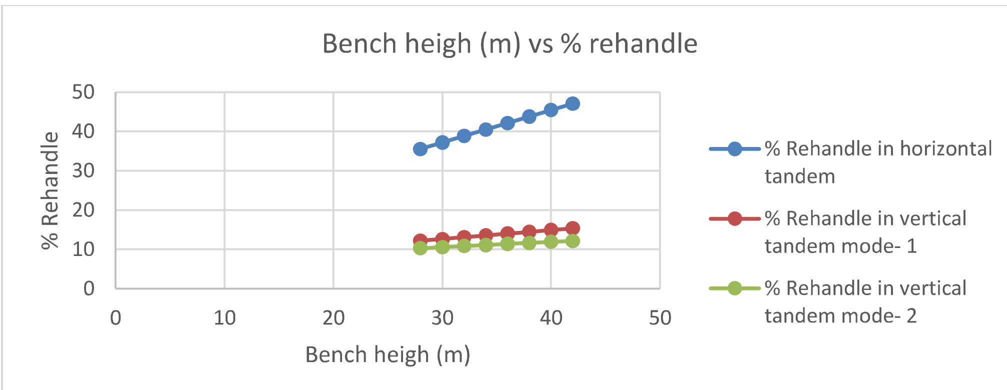

Figure 6.20: Bench height vs % rehandle in all three modes of tandem dragline operation.

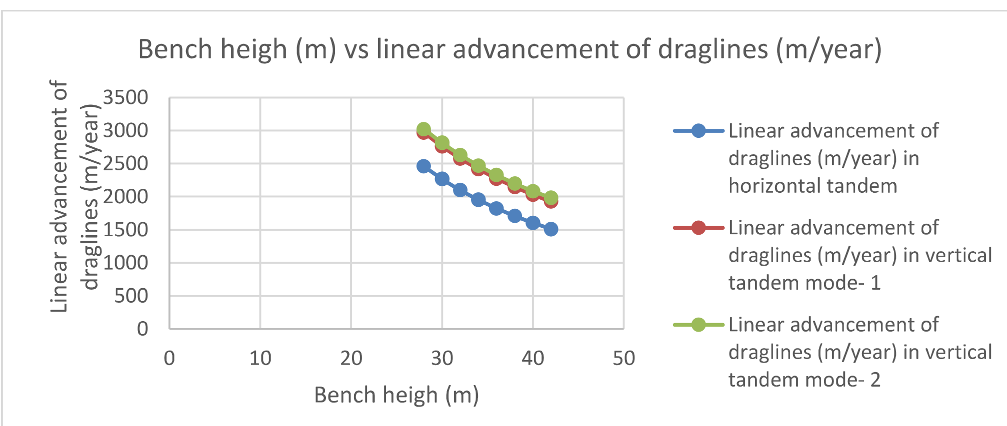

Figure 6.21: Bench height vs linear advancement of draglines (m/year) in all three modes of tandem dragline operation.

6.7 Influence of coal seam thickness

This study analyses the effect of coal seam thickness, which was varied from 9 m to 18 m in intervals of 1 m, while retaining all other relevant parameters. The results have been given in table 6.7.1 for horizontal tandem, table 6.7.2 for vertical tandem mode-1, and table 6.7.3 for vertical tandem mode-2 for each variation in terms of coal exposure, percentage rehandle and linear advancement of the draglines. A typical three-dimensional balancing diagram is illustrated in figure 6.7.1 and the other diagrams are available in the Appendix 3 (Figure 6.7.2 to 6.7.6).

For all three modes of tandem dragline operation, a summary of important parameters like rate of coal exposure, percentage rehandle, and linear advancement of dragline per year with variation in coal seam thickness are graphically represented in figure 6.22, 6.23 and 6.24. From these figures and table, following conclusions can be drawn

(i) As seam thickness increases, the rate of coal being exposed also increases, but the percentage of coal being rehandled and the advancement the dragline for each mode remains relatively steady since they are proportional to the thickness of the seam.

(ii) As the thickness of the seams becomes more, the volume of the spoil dump needed to store the materials also rises. For example, one metre of linear advancement in a seam of 12 m thickness and 90 m cut width will produce 1080 m^3 (90 m x 12 m x 1 m) of spoil dump space. If the thickness is increased to 18 m, the amount of space created will be 1620 m^3 (90 m x 18 m x 1 m). Therefore, the amount of space for spoil dumping increases with increase in seam thickness, which in turn provides more room for dumping.

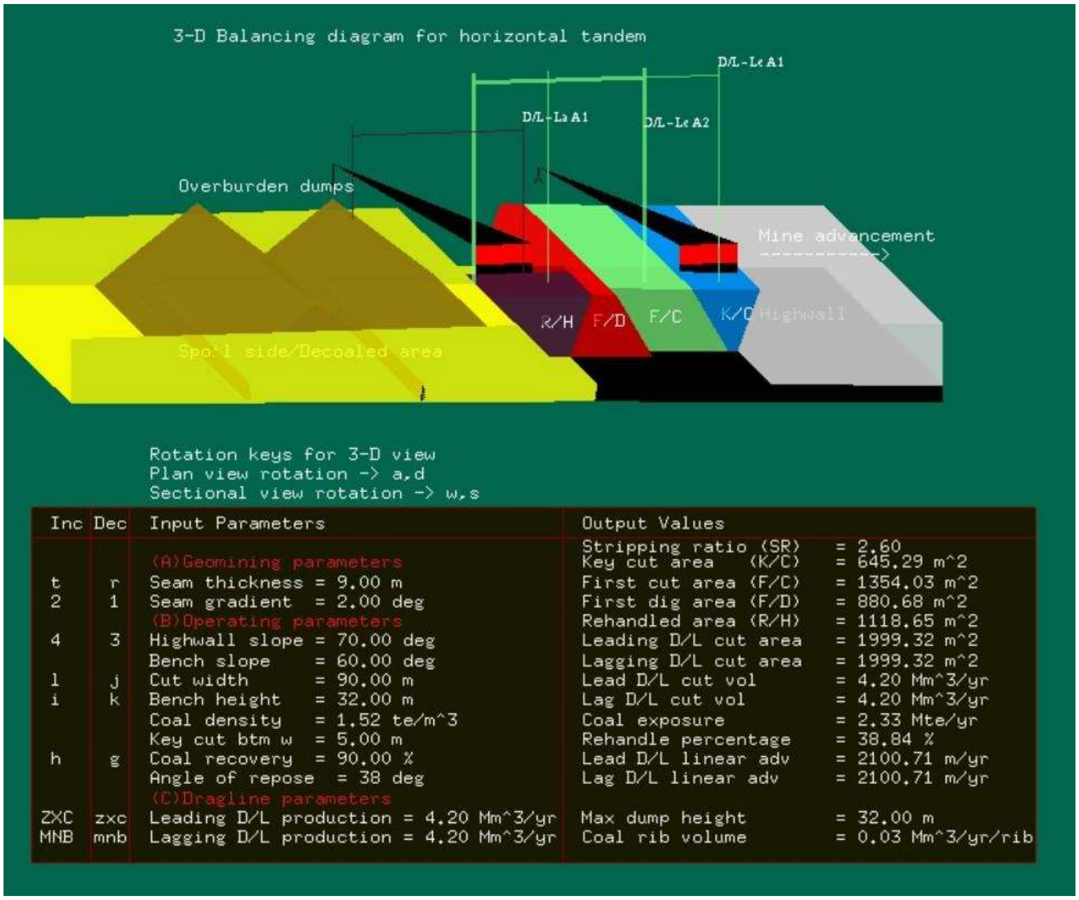

Figure 6.7.1: Three-dimensional balancing diagram for 9 m thick coal seam

Table 6.7.1: Performance in horizontal tandem with variation of seam thickness.

Sl No.	Seam thickness (m)	Leading dragline (Mm^3/ year)	Lagging dragline (Mm^3/ year)	Key cut Area (K/C) (m^2)	First cut Area (F/C) (m^2)	First dig Area (F/D) (m^2)	Rehandled Area (R/H) (m^2)	Coal exposure (Mte/ year)	% Rehandle	Linear advancement Of Leading/ Lagging dragline (m/year)
1	9	4.20	4.20	645.29	1354.03	880.68	1118.65	2.33	38.84	2100.71
2	10	4.20	4.20	645.29	1354.03	880.68	1118.65	2.59	38.84	2100.71
3	11	4.20	4.20	645.29	1354.03	880.68	1118.65	2.85	38.84	2100.71
4	12	4.20	4.20	645.29	1354.03	880.68	1118.65	3.10	38.84	2100.71
5	13	4.20	4.20	645.29	1354.03	880.68	1118.65	3.36	38.84	2100.71
6	14	4.20	4.20	645.29	1354.03	880.68	1118.65	3.62	38.84	2100.71
7	15	4.20	4.20	645.29	1354.03	880.68	1118.65	3.88	38.84	2100.71
8	16	4.20	4.20	645.29	1354.03	880.68	1118.65	4.14	38.84	2100.71
9	17	4.20	4.20	645.29	1354.03	880.68	1118.65	4.40	38.84	2100.71

10	18	4.20	4.20	645.29	1354.03	880.68	1118.65	4.66	38.84	2100.71

Table 6.7.2: Performance in vertical tandem mode-1 with variation of seam thickness.

Sl No.	Seam thickness	Leading dragline (Mm^3/ year)	Lagging dragline (Mm^3/ year)	Top cut area (T/C) (m^2)	Key cut area (K/C) (m^2)	First dig area (F/D) (m^2)	Rehandled area (R/H) (m^2)	Coal exposure (Mte/ year)	% Rehandle	Linear advancement of leading/ lagging dragline (m/year)	Upper bench + lower bench (m)
1	9	4.20	4.20	1423.69	204.99	1251.32	377.35	2.86	13.10	2578.77	15.82 +16.18
2	10	4.20	4.20	1423.69	204.99	1251.32	377.35	3.17	13.10	2578.77	15.82 +16.18
3	11	4.20	4.20	1423.69	204.99	1251.32	377.35	3.49	13.10	2578.77	15.82 +16.18
4	12	4.20	4.20	1423.69	204.99	1251.32	377.35	3.81	13.10	2578.77	15.82 +16.18
5	13	4.20	4.20	1423.69	204.99	1251.32	377.35	4.13	13.10	2578.77	15.82 +16.18

6	14	4.20	4.20	1423.69	204.99	1251.32	377.35	4.44	13.10	2578.77	15.82 +16.18
7	15	4.20	4.20	1423.69	204.99	1251.32	377.35	4.76	13.10	2578.77	15.82 +16.18
8	16	4.20	4.20	1423.69	204.99	1251.32	377.35	5.08	13.10	2578.77	15.82 +16.18
9	17	4.20	4.20	1423.69	204.99	1251.32	377.35	5.40	13.10	2578.77	15.82 +16.18
10	18	4.20	4.20	1423.69	204.99	1251.32	377.35	5.71	13.10	2578.77	15.82 +16.18

Table 6.7.3: Performance in vertical tandem mode-2 with variation of seam thickness.

Sl No.	Seam thickness	Leading dragline (Mm^3/ year)	Lagging dragline (Mm^3/ year)	Top cut area (T/C) (m^2)	Key cut area (K/C) (m^2)	First dig area (F/D) (m^2)	Rehandled area (R/H) (m^2)	Coal exposure (Mte/ year)	% Rehandle	Linear advancement of leading/ lagging dragline (m/year)	Upper bench + lower bench (m)
1	9	4.20	4.20	1596.21	167.75	1116.04	312.42	2.92	10.85	2631.23	17.74 +14.26

2	10	4.20	4.20	1596.21	167.75	1116.04	312.42	3.24	10.85	2631.23	17.74 +14.26
3	11	4.20	4.20	1596.21	167.75	1116.04	312.42	3.56	10.85	2631.23	17.74 +14.26
4	12	4.20	4.20	1596.21	167.75	1116.04	312.42	3.89	10.85	2631.23	17.74 +14.26
5	13	4.20	4.20	1596.21	167.75	1116.04	312.42	4.21	10.85	2631.23	17.74 +14.26
6	14	4.20	4.20	1596.21	167.75	1116.04	312.42	4.54	10.85	2631.23	17.74 +14.26
7	15	4.20	4.20	1596.21	167.75	1116.04	312.42	4.86	10.85	2631.23	17.74 +14.26
8	16	4.20	4.20	1596.21	167.75	1116.04	312.42	5.18	10.85	2631.23	17.74 +14.26
9	17	4.20	4.20	1596.21	167.75	1116.04	312.42	5.51	10.85	2631.23	17.74 +14.26
10	18	4.20	4.20	1596.21	167.75	1116.04	312.42	5.83	10.85	2631.23	17.74 +14.26

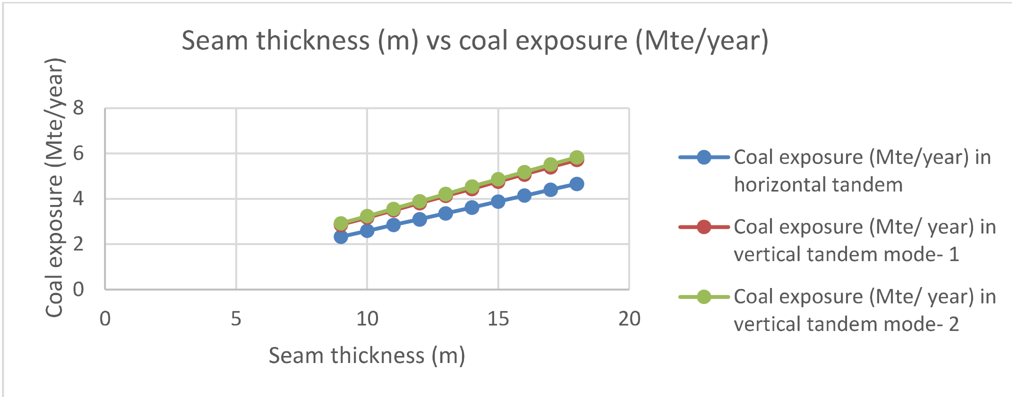

Figure 6.22: Coal seam thickness vs rate of coal exposure (Mte/year) in all three modes of tandem dragline operation.

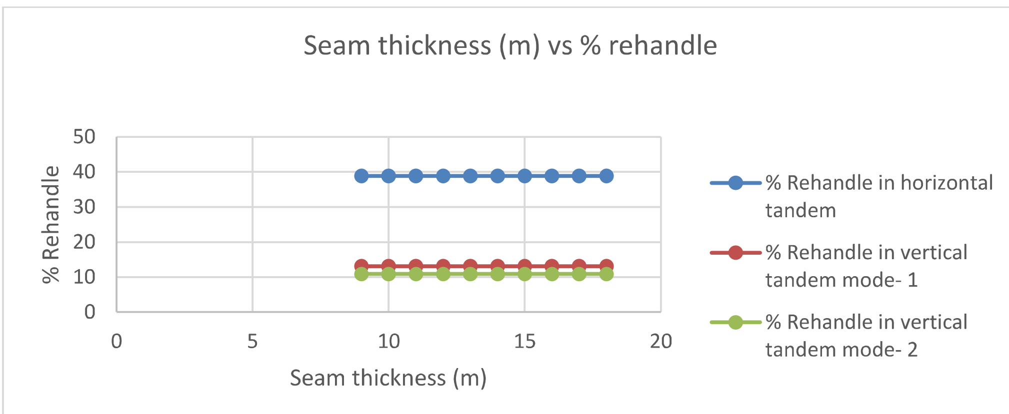

Figure 6.23: Coal seam thickness vs % rehandle in all three modes of tandem dragline operation.

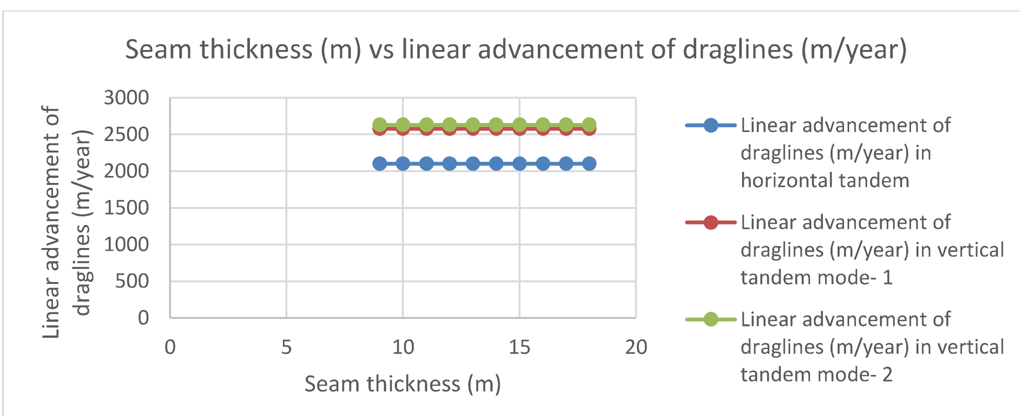

Figure 6.24: Coal seam thickness vs linear advancement of draglines (m/year) in all three modes of tandem dragline operation.

6.8 Influence of seam gradient

This study analyses the effect of coal seam gradient, which was varied from 0° to 5° in interval of 1°, while retaining all other relevant parameters. The results have been given in table 6.8.1 for horizontal tandem, table 6.8.2 for vertical tandem mode-1, and table 6.8.3 for vertical tandem mode-2 for each variation in terms of coal exposure, percentage rehandle and linear advancement of the draglines. A typical three-dimensional balancing diagram is illustrated in figure 6.8.1, and the other diagrams are available in the Appendix 3 (Figure 6.8.2 to 6.8.6).

For all three modes of tandem dragline operation, a summary of important parameters like rate of coal exposure, percentage rehandle, and linear advancement of dragline per year with variation in coal seam gradient are graphically represented in figure 6.25, 6.26 and 6.27. From these figures and table, following conclusions can be drawn.

The rate of coal exposure, rehandle percentage, and linear advancement of draglines are consistent in vertical mode of operation, whereas they are slightly varying in horizontal tandem operation. This is because, according to the assumptions set out in Chapter 3, the overburden layers and coal seams keep the same gradient in the mining advance side, while the overburden dump surface on the spoil side is thought to be level. Consequently, the rehandle area decreases as the seam gradient rises in horizontal tandem, resulting in an increase in linear advancement of draglines and coal exposure. This phenomenon also takes place in vertical mode of operation, but it is not very noticeable as the rehandle is minimal in vertical tandem when compared to horizontal tandem, therefore, it can be disregarded in this circumstance. Changes in the inclination of the seam unto some degrees are advantageous for dragline operation and have minimal influence on the excavation efficiency.

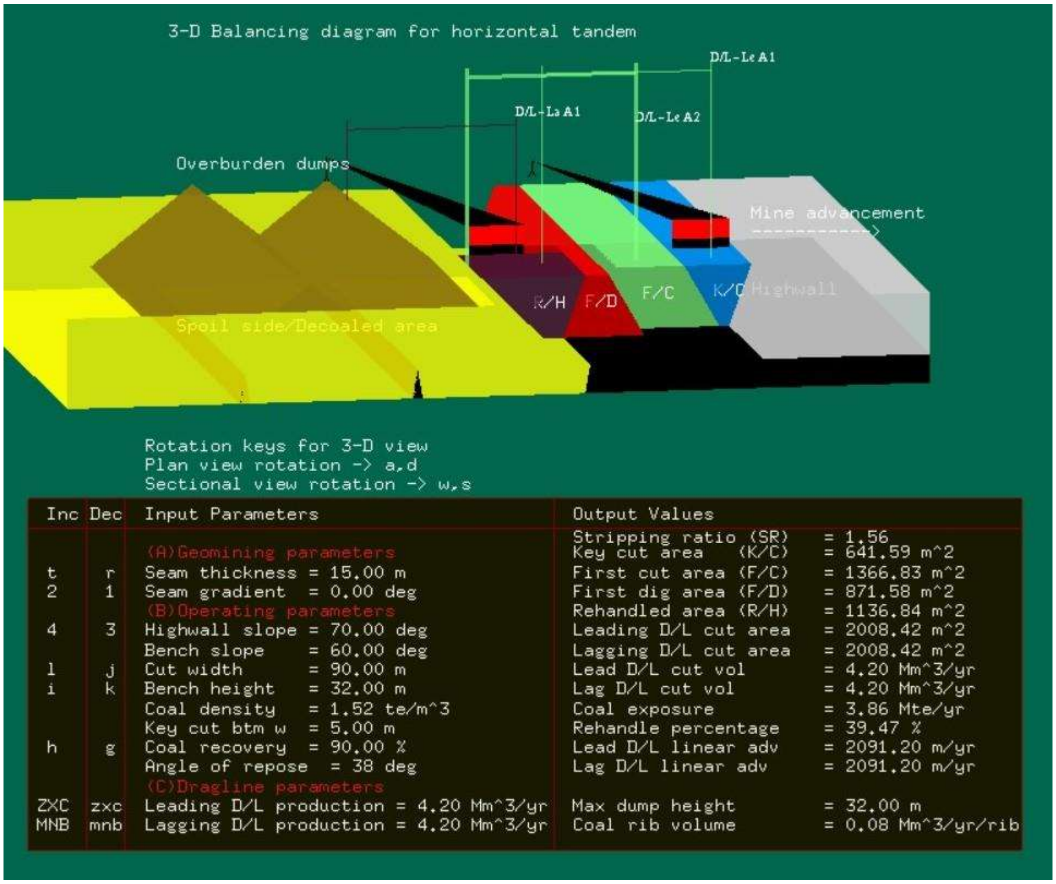

Figure 6.8.1: Three-dimensional balancing diagram for coal seam inclination of 0 degree

Table 6.8.1: Performance in horizontal tandem with variation of seam gradient.

Sl No.	Seam gradient degree	Leading dragline (Mm^3/ year)	Lagging dragline (Mm^3/ year)	Key cut Area (K/C) (m^2)	First cut Area (F/C) (m^2)	First dig Area (F/D) (m^2)	Rehandled Area (R/H) (m^2)	Coal exposure (Mte/ year)	% Rehandle	Linear advancement Of Leading/ Lagging dragline (m/year)
1	0	4.20	4.20	641.59	1366.83	871.58	1136.84	3.86	39.47	2091.20
2	1	4.20	4.20	643.40	1360.45	876.14	1127.71	3.87	39.16	2095.96
3	2	4.20	4.20	645.29	1354.03	880.68	1118.65	3.88	38.84	2100.71
4	3	4.20	4.20	647.26	1347.55	885.19	1109.62	3.89	38.53	2105.46
5	4	4.20	4.20	649.32	1341.01	889.68	1100.65	3.90	38.22	2110.21
6	5	4.20	4.20	651.46	1334.39	894.15	1091.71	3.91	37.91	2114.96

Table 6.8.2: Performance in vertical tandem mode-1 with variation of seam gradient.

Sl No.	Seam gradient degree	Leading dragline (Mm^3/ year)	Lagging dragline (Mm^3/ year)	Top cut area (T/C) (m^2)	Key cut area (K/C) (m^2)	First dig area (F/D) (m^2)	Rehandled area (R/H) (m^2)	Coal exposure (Mte/ year)	% Rehandle	Linear advancement of leading/ lagging dragline (m/year)	Upper bench + lower bench (m)
1	0	4.20	4.20	1427.60	203.17	1249.23	381.52	4.76	13.25	2575.47	15.86 +16.14
2	1	4.20	4.20	1425.65	204.07	1250.28	379.43	4.76	13.17	2577.13	15.84 +16.16
3	2	4.20	4.20	1423.69	204.99	1251.32	377.35	4.76	13.10	2578.77	15.82 +16.18
4	3	4.20	4.20	1421.70	205.95	1252.35	375.29	4.77	13.03	2580.41	15.80 +16.20
5	4	4.20	4.20	1419.69	206.93	1253.38	373.23	4.77	12.96	2582.04	15.77 +16.23
6	5	4.20	4.20	1417.64	207.95	1254.40	371.18	4.77	12.89	2583.67	15.75 +16.25

Table 6.8.3: Performance in vertical tandem mode-2 with variation of seam gradient.

Sl No.	Seam gradient degree	Leading dragline (Mm^3/ year)	Lagging dragline (Mm^3/ year)	Top cut area (T/C) (m^2)	Key cut area (K/C) (m^2)	First dig area (F/D) (m^2)	Rehandled area (R/H) (m^2)	Coal exposure (Mte/ year)	% Rehandle	Linear advancement of leading/ lagging dragline (m/year)	Upper bench + lower bench (m)
1	0	4.20	4.20	1598.23	166.60	1115.17	316.47	4.85	10.99	2627.90	17.76 +14.24
2	1	4.20	4.20	1597.22	167.17	1115.61	314.44	4.86	10.92	2629.56	17.75 +14.25
3	2	4.20	4.20	1596.21	167.75	1116.04	312.42	4.86	10.85	2631.23	17.74 +14.26
4	3	4.20	4.20	1595.21	168.35	1116.45	310.40	4.86	10.78	2632.89	17.72 +14.28
5	4	4.20	4.20	1594.20	168.97	1116.84	308.39	4.87	10.71	2634.56	17.71 +14.29
6	5	4.20	4.20	1593.20	169.60	1117.20	306.37	4.87	10.64	2636.21	17.70 +14.30

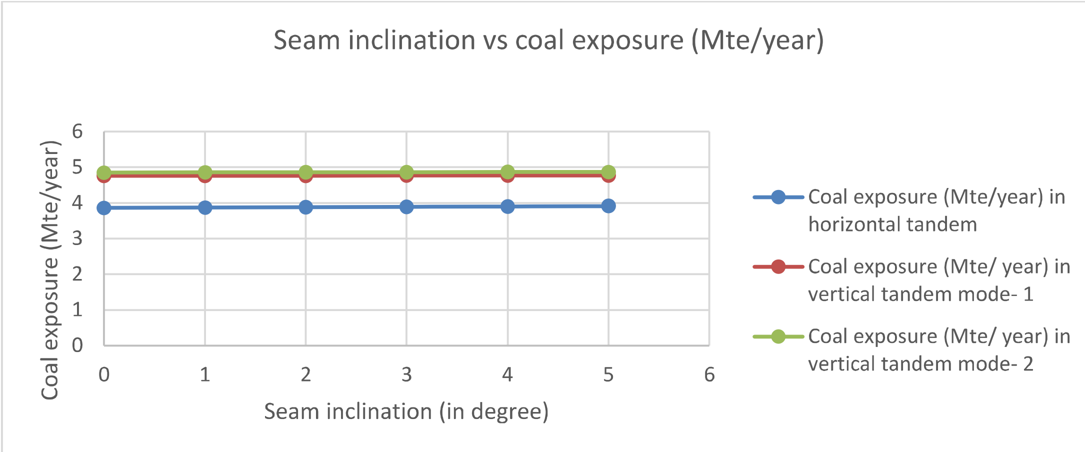

Figure 6.25: Coal seam inclination vs rate of coal exposure (Mte/year) in all three modes of tandem dragline operation.

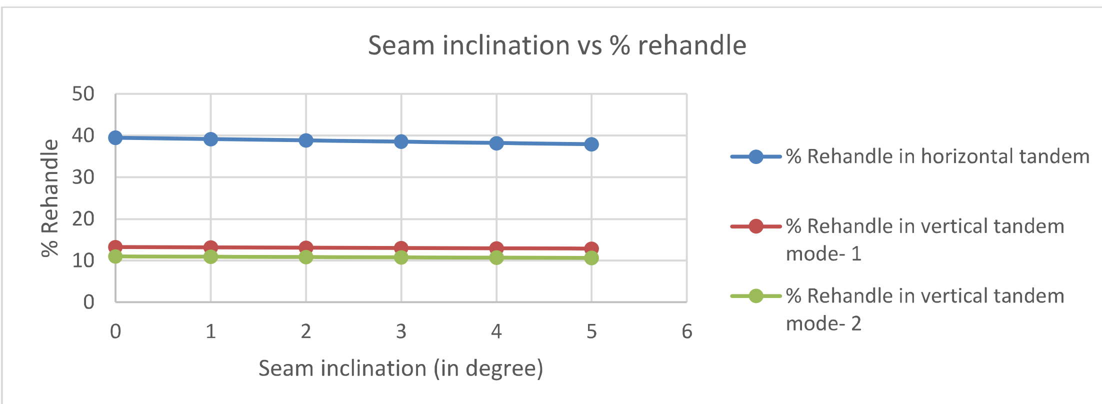

Figure 6.26: Coal seam inclination vs % rehandle in all three modes of tandem dragline operation.

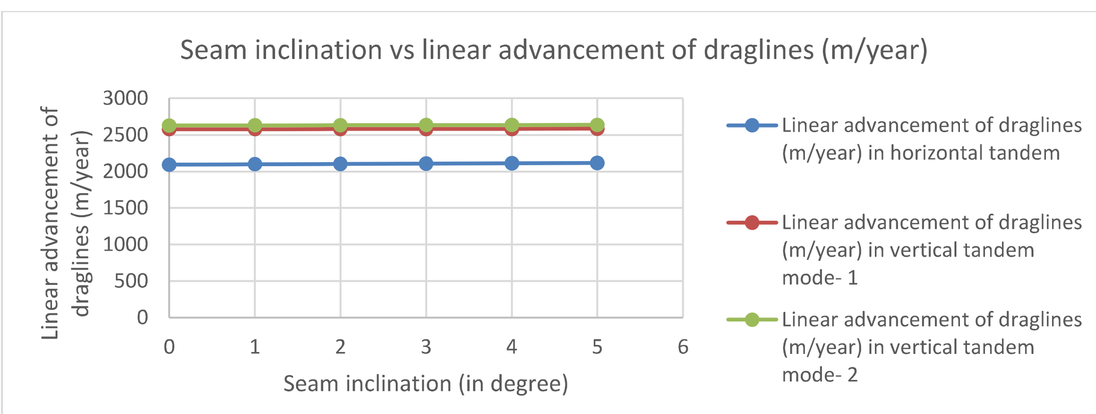

Figure 6.27: Coal seam inclination vs linear advancement of draglines (m/year) in all three modes of tandem dragline operation.

6.9 To find the best combination of cut width and bench height within the possible working range of draglines

Case 1: Horizontal tandem

This study investigates the effect of changing the cut width from 70 to 105 m in increments of 5 m while likewise varying the stripping bench height from 25 to 35 m in steps of 5 m, with the aim of determining the most appropriate cut width and bench height for horizontal tandem dragline operations under prevailing field conditions. The parameters related to operations, geo-mining, and machine specification were all kept unchanged as discussed earlier. The results of the three-dimensional balancing diagrams were compiled into table 6.9.1 for a combination of same annual production capacity of 4.20 Mm^3 leading and lagging draglines. The relevant three-dimensional balancing diagrams are appended in appendix 3 (figure 6.9.1 to 6.9.9)

From examining table 6.9.1 and figures 6.9.1 to 6.9.9 in the Appendix 3, it appears that using a combination of cut width of 100 m and bench height of 25 m in horizontal tandem operation might be a best option. This could result in the highest rate of coal exposure and the lowest amount of rehandle. However, when the cut width goes beyond 100 m (i.e., 105 m in this case, as shown by figures 6.9.3, 6.9.6 and 6.9.9 in Appendix 3), the overburden removed by the leading dragline from the key cut cannot be deposited into the de-coaled area, due to the lack of adequate reach of the leading dragline.

The most effective pairing of cut width and bench height must be compatible with the lagging and leading dragline annual production capacities and may need to be adapted based on other geological or mining limitations.

Table 6.9.1: Influence of cut width and bench height in horizontal tandem for leading and lagging draglines of equal annual production capacity of 4.20 Mm^3.

Sr. No.	Variation		Horizontal tandem		
	Cut width (m)	Bench height (m)	Coal exposure (Mte/year)	% Rehandle	Linear advancement (m/year)
1	70	25	4.84	42.51	3368.07
2	75	25	4.94	39.68	3207.32
3	80	25	5.03	37.20	3061.21
4	85	25	5.11	35.01	2927.84
5	90	25	5.18	33.07	2805.60
6	95	25	5.25	31.33	2693.16
7	**100**	**25**	**5.31**	**29.76**	**2589.39**
8	105	25	5.37	28.34	2493.31
9	70	30	3.89	47.82	2706.00
10	75	30	3.97	44.63	2581.27
11	80	30	4.05	41.84	2467.53
12	85	30	4.12	39.38	2363.39
13	90	30	4.19	37.19	2267.69
14	95	30	4.25	35.24	2179.43
15	100	30	4.30	33.47	2097.79
16	105	30	4.36	31.88	2022.04
17	70	35	3.22	53.12	2239.16
18	75	35	3.29	49.58	2139.36
19	80	35	3.36	46.48	2048.08
20	85	35	3.43	43.74	1964.27
21	90	35	3.48	41.31	1887.04
22	95	35	3.54	39.14	1815.66
23	100	35	3.59	37.18	1749.49
24	105	35	3.64	35.41	1687.97

Case 2: Vertical tandem operation mode 1

This study investigates the effect of changing the cut width from 65 to 100 m in increments of 5 m while likewise varying the stripping bench height from 30 to 40 m in steps of 5 m, with the aim of determining the most appropriate cut width and bench height for vertical tandem mode-1 operations under prevailing field conditions. The parameters related to operations, geo-mining, and machine specification were all kept unchanged as discussed earlier. The results of the three-dimensional balancing diagrams were compiled into table 6.9.2 for a combination of same annual production capacity of 4.20 Mm^3 leading and lagging draglines. The relevant three-dimensional balancing diagrams are appended in appendix 3 (figure 6.9.10 to 6.9.18)

From examining table 6.9.2 and figures 6.9.10 to 6.9.18 in the Appendix 3, it appears that using a combination of cut width of 95 m and bench height of 30 m in vertical tandem mode-1 operation might be a best option. This could result in a highest rate of coal exposure and a lowest amount of rehandle. However, when the cut width goes beyond 95 m (i.e., 100 m in this case, as shown by figures 6.9.12, 6.9.15 and 6.9.18 in Appendix 3) the overburden removed by the leading dragline from the key cut cannot be deposited into the de-coaled area, due to the lack of adequate reach of the leading dragline.

Table 6.9.2: Influence of cut width and bench height in vertical tandem mode-1 for leading and lagging draglines of equal annual production capacity of 4.20 Mm^3.

Sr. No.	Variation		Vertical tandem mode - 1		
	Cut Width	Bench Height	Coal exp	% Reh	Linear Adv
1	65	30	4.88	17.63	3661.94
2	70	30	4.94	16.35	3437.93
3	75	30	4.99	15.24	3239.64
4	80	30	5.03	14.27	3062.92
5	85	30	5.07	13.42	2904.44

6	90	30	5.10	12.66	2761.51
7	**95**	**30**	**5.13**	**11.98**	**2631.96**
8	100	30	5.16	11.38	2514.00
9	65	35	4.13	19.22	3096.99
10	70	35	4.18	17.81	2910.21
11	75	35	4.22	16.59	2744.54
12	80	35	4.26	15.53	2596.65
13	85	35	4.30	14.60	2463.82
14	90	35	4.33	13.77	2343.87
15	95	35	4.36	13.03	2235.03
16	100	35	4.38	12.37	2135.82
17	65	40	3.57	20.84	2673.62
18	70	40	3.61	19.30	2514.69
19	75	40	3.65	17.97	2373.46
20	80	40	3.69	16.81	2247.14
21	85	40	3.72	15.80	2133.53
22	90	40	3.75	14.90	2030.80
23	95	40	3.78	14.09	1937.46
24	100	40	3.80	13.37	1852.29

Case 3: Vertical tandem mode 2

This study investigates the effect of changing the cut width from 60 to 95 m in increments of 5 m while likewise varying the stripping bench height from 35 to 45 m in steps of 5 m, with the aim of determining the most appropriate cut width and bench height for vertical tandem mode-2 operations under prevailing field conditions. The parameters related to operations, geo-mining, and machine specification were all kept unchanged as discussed earlier. The results of the three-dimensional balancing diagrams were compiled into table 6.9.3 for a combination of same annual production capacity of

4.20 Mm^3 leading and lagging draglines. The relevant three-dimensional balancing diagrams are appended in appendix 3 (figure 6.9.19 to 6.9.27)

Table 6.9.3: Influence of cut width and bench height in vertical tandem mode-2 for leading and lagging draglines of equal annual production capacity of 4.20 Mm^3.

Sr. No.	Variation		Vertical tandem mode - 2		
	Cut Width	Bench Height	Coal exp	% Reh	Linear Adv
1	60	35	4.26	15.65	3458.61
2	65	35	4.29	14.69	3219.24
3	70	35	4.33	13.85	3011.53
4	75	35	4.35	13.09	2829.49
5	80	35	4.38	12.42	2668.57
6	85	35	4.40	11.81	2525.27
7	**90**	**35**	**4.43**	**11.26**	**2396.79**
8	95	35	4.45	10.76	2280.93
9	60	40	3.70	16.50	3004.39
10	65	40	3.73	15.50	2797.11
11	70	40	3.76	14.62	2617.23
12	75	40	3.79	13.84	2459.55
13	80	40	3.81	13.14	2320.15
14	85	40	3.83	12.50	2195.98
15	90	40	3.85	11.93	2084.64
16	95	40	3.87	11.40	1984.23
17	60	45	3.27	17.31	2652.11
18	65	45	3.29	16.28	2469.66
19	70	45	3.32	15.38	2311.30
20	75	45	3.34	14.56	2172.47
21	80	45	3.36	13.84	2049.73
22	85	45	3.38	13.18	1940.38
23	90	45	3.40	12.58	1842.31

24	95	45	3.42	12.03	1753.85

(i) From examining table 6.9.3 and figures figure 6.9.19 to 6.9.27 in the Appendix 3, it appears that using a combination of cut width of 90 m and bench height of 35 m in vertical tandem mode-2 operation might be a best option. This could result in the highest rate of coal exposure and the lowest amount of rehandle. However, when the cut width goes beyond 90 m (i.e., 95 m in this case, as shown by figures 6.9.21, 6.9.24 and 6.9.27 in Appendix 3), the overburden removed by the leading dragline from the key cut cannot be deposited into the de-coaled area, due to the lack of adequate reach of the leading dragline.

(ii) An interesting occurrence was observed in this case. As the bench height increases while the cut width stays the same, the reach requirement of the leading dragline also increases. This is because the centre of gravity of the upper bench face block is relocated away from the area that has been de-coaled, and thus extra reach from the leading dragline is necessary. This has been observed in previous case also, but the reach of the leading dragline is sufficient to tackle the issue.