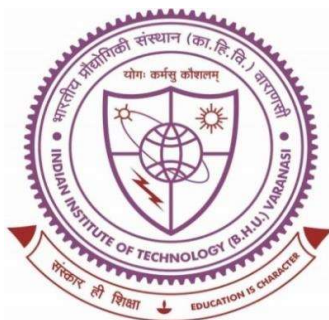


**THREE-DIMENSIONAL BALANCING DIAGRAM FOR PLANNING
OF TANDEM DRAGLINE OPERATIONS IN LARGE OPENCAST
MINES**



Thesis submitted in partial fulfilment for the

Award of Degree

Doctor of Philosophy

by

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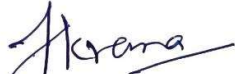
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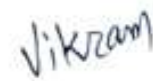
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Date: 27/12/2022

Place: Varanasi



Vikram Seervi

Dedicated to my Beloved

Niece, Figyasa

CONTENTS

CHAPTER 1 INTRODUCTION AND OBJECTIVES OF THE STUDY	1
1.1 Introduction	1
1.1.1 Energy scenario and importance of surface coal mining in India	1
1.1.2 Overburden removal in surface coal mining	2
1.1.3 A comparison of overburden removal with various HEMM.....	3
1.1.4 Global dragline production	5
1.1.5 History and assessment of dragline mining methods in India	5
1.1.6 Tandem dragline operation	10
1.1.7 Planning of tandem dragline operation.....	11
1.1.8 Planning of dragline operations using computer	12
1.2 Objectives of the study	13
1.3 Outline of the thesis.....	15
CHAPTER 2 LITERATURE REVIEW	17
2.1 History of the dragline.....	17
2.2 An introduction to dragline	17
2.3 Classifications of dragline.....	19
2.4 Dragline applicability conditions in mining operations	19
2.5 Dragline applications.....	20
2.6 Dragline advantages, disadvantages, and limitations.....	20
2.6.1 Advantages	20
2.6.2 Disadvantages	21
2.6.3 Limitations.....	22
2.7 Dragline modes of operation	22
2.7.1 Normal underhand digging	23

2.7.2 Overhand digging or chop-down operation.....	23
2.7.3 Pull-back operation from spoil side.....	24
2.8 Dragline stripping methods.....	25
2.8.1 Single seam methods.....	25
2.8.2 Tandem dragline method.....	28
2.8.3 Multi-seam methods.....	38
CHAPTER 3 - PLANNING OF DRAGLINE OPERATION AND DEVELOPMENT OF THREE-DIMENSIONAL BALANCING DIAGRAM.....	40
3.1 Introduction.....	40
3.2 Planning for dragline operation.....	40
3.2.1 Dragline method selection.....	40
3.2.2 Dragline machine size selection.....	41
3.2.3 Macro-level operational planning.....	41
3.2.4 Micro-level operational planning.....	45
3.2.5 Balancing diagram.....	48
CHAPTER 4 VALIDATION AND APPLICATION OF THE DEVELOPED COMPUTER PROGRAM.....	65
4.1 Validation of the computer program with actual field conditions.....	65
4.2 Applications of the developed model.....	69
CHAPTER 5 FIELD STUDIES.....	70
5.1 General.....	70
5.2 Brief information about NCL.....	71
5.3 Nighai project.....	75
5.3.1 General information about Nighai project.....	75
5.3.2 Mineable reserves(MR),overburden(OBR), and stripping ratio(SR).....	75
5.3.3 Quarry parameters.....	76
5.3.4 Details of major HEMM equipment deployed in the project.....	76
5.3.5 Method of working.....	77

5.4 Dhudhichua project	79
5.4.1 General information about Dhudhichua project	79
5.4.2 Mineable reserves(MR),overburden(OBR), and stripping ratio(SR)	80
5.4.3 Description of coal seams	80
5.4.4 Details of major HEMM equipment deployed in the project	82
5.4.5 Method of working and its status	83
5.5 Bina project	84
5.5.1 General information about Bina project	84
5.5.2 Geology and coal reserves	85
5.5.3 Details of major HEMM equipment deployed in the project	85
5.5.4 Method of working	86
5.6 Jayant project.....	88
5.6.1 General information about Jayant project	88
5.6.2 Summary of coal reserve, OB estimate, and other vital parameters.....	88
5.6.3 Description of coal seams	89
5.6.4 Mineable reserves(MR),overburden(OBR), and stripping ratio(SR)	90
5.6.5 Details of major HEMM equipment deployed in the project	91
5.6.6 Method of working	92
5.7 Data collection from field study.....	94
5.8 Dragline monitoring system	94
5.9 Determination of annual production capacity of different draglines	97
5.9.1 Average cycle time	98
5.9.2 Average annual production of different capacity draglines for various swing angles	99
CHAPTER 6 RESULTS AND DISCUSSION THROUGH PARAMETRIC ANALYSIS IN THE CASE STUDIES	101
6.1 Annual production of leading dragline is less than the annual production of lagging dragline.....	102

6.2 Annual production capacity of leading and lagging dragline are same	110
6.3 Annual production capacity of leading dragline is greater than the annual production capacity of lagging dragline.....	117
6.4 Relationship equations	124
6.5 Influence of cut width	141
6.6 Influence of stripping bench height	149
6.7 Influence of coal seam thickness	156
6.8 Influence of seam gradient	163
6.9 To find the best combination of cut width and bench height within the possible working range of draglines	169
CHAPTER 7 DRAGLINE COST ANALYSIS.....	175
7.1 Cost analysis	175
7.1.1 Calculation of cost of dragline operation in mines under case study	175
CHAPTER 8 CONCLUSIONS AND RECOMMENDATIONS FOR FUTURE RESEARCH	180
8.1 Conclusions.....	180
8.2 Recommendations for future research	181
REFERENCES	183
APPENDIX-1 - THREE-DIMENSIONAL BALANCING DIAGRAMS	193
APPENDIX-2 Computer program codes of three-dimensional balancing diagram for horizontal tandem operation	230
APPENDIX-3 Computer program codes of three-dimensional balancing diagram for vertical tandem operation (mode-1 and mode-2).....	269
APPENDIX 4: LIST OF PUBLICATIONS	312

LIST FO FIGURES

Figure 1.1: Respective shares of surface and underground mining in India's annual coal production over the past ten years.	2
Figure 1.2: Annual removal of overburden in India.	3
Figure 1.3 A dragline machinery. (Source: https://mining.komatsu/en-in/product-details/p-h-9020c)	5
Figure 1.4: Global production statistics of draglines. (Dragline Dictionary, 4th Edition, PwC)	5
Figure 2.1 Schematic diagram of a typical dragline (Humphrey, 1990).	17
Figure 2.2: Dragline removing key cut material in its normal underhand mode (Mirabediny,1998).	23
Figure 2.3: Dragline removing an advance bench material in an overhand chopping (Mirabediny,1998).	24
Figure 2.4: Material is being pulled back by a dragline by slicing against the highwall from a pad on the spoil side (Mirabediny,1998).	25
Figure 2.5: Plan and sectional view of simple side casting method (Mirabediny,1998). ..	26
Figure 2.6: Cross-sectional view of a standard extended bench method combined with a cast blasting technique (Mirabediny,1998).	27
Figure 2.7: Cross-sectional view of the split bench dragline digging method (Mirabediny,1998).	27
Figure 2.8: Cross-sectional view of extended key cut method (Akhundov and Demirel,2019).	28
Figure 2.9: Plan of mining system in horizontal tandem (Kishore & Jaiswal, 2004).	31
Figure 2.10: Cross-section showing draglines in horizontal tandem (Kishore & Jaiswal, 2004).	31
Figure 2.11: Two draglines working in horizontal tandem with key terms elaborated. (Modified from Mousa and Rai,2015)	31
Figure 2.12: Plan of mining system in vertical tandem (Kishore & Jaiswal, 2004).	35
Figure 2.13: Cross-section showing draglines in vertical tandem (Kishore & Jaiswal, 2004).	35
Figure 2.14: Two draglines working in vertical tandem at Bina mine of NCL.	36
Figure 2.15: Three seam operation: Single highwall and double lowwall method. (Mirabediny,1998).	39

Figure 3.1: A dragline at NCL mine excavating blasted overburden material from a key cut.	44
Figure 3.2: Cast blasting profile of blasted overburden bench (Darling,2011).	45
Figure 3.3: Block diagram of input and output parameters of the program.	62
Figure 3.4: A typical 3-D balancing diagram for horizontal tandem.	63
Figure 3.5: A typical 3-D balancing diagram for vertical tandem.	64
Figure 3.6: Research methodology.	64
Figure 4.1: Computer generated three-dimensional balancing diagram for Nighai mine.	65
Figure 4.2: Computer generated three-dimensional balancing diagram for Dhudhichua mine.	66
Figure 4.3: Computer generated three-dimensional balancing diagram for Jayant mine.	66
Figure 4.4: Computer generated three-dimensional balancing diagram for Bina mine.	67
Figure 5.1: Location map of the study area.	73
Figure 5.2: Master plan of Moher basin showing study areas in black circles.	73
Figure 5.3: Coal production from NCL in last 5 years and target for upcoming years (in)	74
Figure 5.4: Cross-sectional view of Nigahi mine.	76
Figure 5.5: Dragline working in horizontal tandem at Nighai project.	79
Figure 5.6: Section of seams and partings in mines with their mining strategy in Dhudhichua project.	82
Figure 5.7: Dragline working in horizontal tandem at Dhudhichua project.	84
Figure 5.8: Dragline working in vertical tandem at Bina project.	88
Figure 5.9: Overall view of the different coal deposition and overburden at Jayant opencast project.	90
Figure 5.10: Dragline working in horizontal tandem at Jayant project.	93
Figure 5.11: Leica on-board monitoring system of a dragline model W-2000 at NCL mine.	95
Figure 5.12: Leica dragline monitoring system showing various dig modes.	96
Figure 5.13: Leica dragline monitoring system showing shift stats summary.	96
Figure 5.14: Leica dragline monitoring system showing cycle time and swing angle information.	97
Figure 6.1.1: Three-dimensional balancing diagram for 1.80 Mm ³ leading and 2.00 Mm ³ lagging dragline.	103

Figure 6.1: Le/La vs rate of coal exposure (Mte/year) in all three modes of tandem dragline operation.	107
Figure 6.2: Le/La vs % rehandle in all three modes of tandem dragline operation.	107
Figure 6.3: Le/La vs linear advancement of draglines (m/year) in all three modes of tandem dragline operation.....	107
Figure 6.2.1: Three-dimensional balancing diagram for 1.80 Mm ³ leading and 1.80 Mm ³ lagging dragline.	112
Figure 6.4: Annual production of leading dragline vs rate of coal exposure (Mte/year) in all three modes of tandem dragline operation.....	116
Figure 6.5: Annual production of leading dragline vs % rehandle in all three modes of tandem dragline operation.....	116
Figure 6.6: Annual production of leading dragline vs linear advancement of draglines (m/year) in all three modes of tandem dragline operation.	116
Figure 6.3.1: Three-dimensional balancing diagram for 1.80 Mm ³ leading and 1.60 Mm ³ lagging dragline	118
Figure 6.7: Le/La vs rate of coal exposure (Mte/year) in all three modes of tandem dragline operation.	123
Figure 6.8: Le/La vs % rehandle in all three modes of tandem dragline operation.	123
Figure 6.9: Le/La vs linear advancement of draglines (m/year) in all three modes of tandem dragline operation.....	123
Figure 6.4.1: Three -dimensional balancing diagram for 3.20 Mm ³ leading and 1.60 Mm ³ lagging dragline	126
Figure 6.10: Annual production of lagging dragline vs rate of coal exposure (Mte/year) in all three modes of tandem dragline operation.....	133
Figure 6.11: Annual production of lagging dragline vs % rehandle in all three modes of tandem dragline operation.....	133
Figure 6.12: Annual production of lagging dragline vs linear advancement of draglines (m/year) in all three modes of tandem dragline operation.	133
Figure 6.13: Annual production of leading dragline vs rate of coal exposure (Mte/year) in all three modes of tandem dragline operation.	140
Figure 6.14: Annual production of leading dragline vs % rehandle in all three modes of tandem dragline operation.....	140
Figure 6.15: Annual production of leading dragline vs linear advancement of draglines (m/year) in all three modes of tandem dragline operation.	140

Figure 6.5.1: Three-dimensional balancing diagram for 55 m cut width	142
Figure 6.16: Cut width vs rate of coal exposure (Mte/year) in all three modes of tandem dragline operation.	148
Figure 6.17: Cut width vs % rehandle in all three modes of tandem dragline operation.	148
Figure 6.18: Cut width vs linear advancement of draglines (m/year) in all three modes of tandem dragline operation.	148
Figure 6.6.1: Three-dimensional balancing diagram for 28 m bench height.....	150
Figure 6.19: Bench height vs rate of coal exposure (Mte/year) in all three modes of tandem dragline operation.	155
Figure 6.20: Bench height vs % rehandle in all three modes of tandem dragline operation.	155
Figure 6.21: Bench height vs linear advancement of draglines (m/year) in all three modes of tandem dragline operation.	155
Figure 6.7.1: Three-dimensional balancing diagram for 9 m thick coal seam	157
Figure 6.22: Coal seam thickness vs rate of coal exposure (Mte/year) in all three modes of tandem dragline operation.	162
Figure 6.23: Coal seam thickness vs % rehandle in all three modes of tandem dragline operation.	162
Figure 6.24: Coal seam thickness vs linear advancement of draglines (m/year) in all three modes of tandem dragline operation.....	162
Figure 6.8.1: Three-dimensional balancing diagram for coal seam inclination of 0 degree	164
Figure 6.25: Coal seam inclination vs rate of coal exposure (Mte/year) in all three modes of tandem dragline operation.	168
Figure 6.26: Coal seam inclination vs % rehandle in all three modes of tandem dragline operation.	168
Figure 6.27: Coal seam inclination vs linear advancement of draglines (m/year) in all three modes of tandem dragline operation.....	168
Figure 7.1: Costing flow chart (Modified after Noakes and Lanz, 1993).	175

LIST FO TABLES

Table 1.1: Assessment of dragline mining methods in India (Rai and Singh, 2021).	7
Table 3.1: Input design parameters in the program.	60
Table 4.1 A comparison of computer generated three-dimensional balancing diagram data vs actual filed condition data in different mines.	67
Table: 5.1 Summary of dragline combinations having different modes of operation in the present study.	70
Table 5.2: Mineable reserves(MR),overburden(OBR), and stripping ratio(SR)	75
Table 5.4: Quarry Parameters of Nigahi OCP.	76
Table 5.5: HEMM deployed in the project.	76
Table 5.7: Details of Mineable reserves (MR), overburden(OBR), and stripping ratio(SR) of Dhudhichua project.....	80
Table 5.8: HEMM deployed in the project.	82
Table 5.11: Geology and coal reserves of Bina project.	85
Table 5.12: HEMM deployed in the project.	85
Table 5.14: Summary of coal reserve, OB estimate, and other vital parameters.....	88
Table 5.15: Section-wise, MR, OBR & Av. SR.	90
Table 5.16: HEMM deployed in the project.	91
Table 5.17: Cycle time of different capacity draglines for various swing angles.....	98
Table 5.18: Annual productivity of different draglines.	100
Table 6.1.1: Performance in horizontal tandem when annual production of leading dragline is less than lagging dragline.....	104
Table 6.1.2: Performance in vertical tandem mode-1 when annual production of leading dragline is less than lagging dragline.....	105
Table 6.1.3: Performance in vertical tandem mode-2 when annual production of leading dragline is less than lagging dragline.....	106
Table 6.2.1: Performance in horizontal tandem when annual production of leading and lagging dragline are same.	113
Table 6.2.2: Performance in vertical tandem mode-1 when annual production of leading and lagging dragline are same.....	114
Table 6.2.3: Performance in vertical tandem mode-2 when annual production of leading and lagging dragline are same.....	115

Table 6.3.1: Performance in horizontal tandem when annual production of leading dragline is more than lagging dragline.	119
Table 6.3.2: Performance in vertical tandem mode-1 when annual production of leading dragline is more than lagging dragline.	120
Table 6.3.3: Performance in vertical tandem mode-2 when annual production of leading dragline is more than lagging dragline.	121
Table 6.4.1: Performance in horizontal tandem when annual production of leading dragline is constant and annual production of lagging dragline vary.	127
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.	128
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.	130
Table 6.4.4: Performance in horizontal tandem when annual production of leading dragline is constant and annual production of lagging dragline vary.	134
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.	135
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.	137
Table 6.5.1: Performance in horizontal tandem with variation of cut width.	143
Table 6.5.2: Performance in vertical tandem mode-1 with variation of cut width.	144
Table 6.5.3: Performance in vertical tandem mode-2 with variation of cut width.	146
Table 6.6.1: Performance in horizontal tandem with variation of bench height.	151
Table 6.6.2: Performance in vertical tandem mode-1 with variation of bench height. ..	152
Table 6.6.3: Performance in vertical tandem mode-2 with variation of bench height. ..	153
Table 6.7.1: Performance in horizontal tandem with variation of seam thickness.	158
Table 6.7.2: Performance in vertical tandem mode-1 with variation of seam thickness.	159
Table 6.7.3: Performance in vertical tandem mode-2 with variation of seam thickness.	160
Table 6.8.1: Performance in horizontal tandem with variation of seam gradient.	165
Table 6.8.2: Performance in vertical tandem mode-1 with variation of seam gradient. ..	166
Table 6.8.3: Performance in vertical tandem mode-2 with variation of seam gradient. ..	167
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	169

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	171
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	173
Table 7.1: Various cost of different dragline model.	179

ABSTRACT

The coal industry plays a significant role in the development of the Indian economy. Coal is the most important and abundant fossil fuel in India due to the limited availability of oil and gas. In recent years, with the ever-growing energy needs, the demand for coal has increased drastically and will continue to be a major source of energy well into the next century. Coal is commonly extracted through surface mining methods due to its benefits, including a higher extraction ratio, higher productivity, and fewer safety problems. In surface coal mining, overburden (OB) removal is a significant mining operation and calls for efficient and careful planning for the best utilization of the system.

Overburden removal typically makes up more than 60% of the total mining costs in surface coal mines. The amount of overburden removal and coal production are directly proportional to each other. Over the past four decades, draglines have become increasingly popular for overburden handling because of their flexibility and high production rate. As mines expand and demand higher outputs, either higher capacity draglines with larger bucket sizes and radii or tandem operation of draglines are becoming more common.

In recent years, there has been an increased focus on operating draglines in tandem. This involves using two draglines to work together, either in horizontal tandem or vertical tandem, in order to maximize overburden removal and coal exposure while minimizing rehandling. This helps to make better use of these capital-intensive pieces of equipment. To get the most out of such tandem operation, it is extremely important to identify the key operational parameters that increase the rate of coal exposure and reduce the percentage of rehandling. There are two main aspects that have been identified to

improve the rate of coal exposure, considering geo-mining and machine specification parameters to be constant. The first step to increasing the productivity of draglines is to increase availability and utilization. The second step is to develop efficient and careful pit planning and design. The planning process helps identify operational parameters and how to best utilize resources. It is a blend of engineering and economics. It is good practice for planning engineers to assess the productivity of equipment in a given situation before making further operational plans. This will help ensure more meaningful results.

The current study has looked at the planning and design aspect of tandem dragline operation, taking into account the average annual productivity of draglines based on an actual field study. The key dragline performance and efficiency statistics have been gathered to get the average productivity of different capacity draglines, which is needed for further analysis.

Different seating arrangements of draglines are presented in the form of balancing diagrams to help determine the most effective way to utilize the draglines and minimize rehandling. The diagrams are based on synchronized linear advancement of both draglines and show the dragline cut spoil geometry in two dimensions, as well as bench division in horizontal and vertical tandem operation.

The draglines must be correctly deployed using the balancing diagram for draglines running in tandem. However, regularly drawing balancing diagrams by manually could become expensive, time-consuming, and even inaccurate. In order to quickly and accurately calculate the rate of coal exposure, % rehandle, area of cuts, synchronized linear advancement of each dragline, and stripping bench division; computer graphics are most suited for this task.

The purpose of this study is to conduct parametric and field studies of dragline operations in horizontal and vertical tandem configurations to evaluate the importance of various geo-mining, machine, and operative parameters on annual productivity and to offer suggestions for productivity enhancement.

With the aim of simplifying complex tandem dragline operation, an interactive, graphics-based program was developed in C++ language using OpenGL graphics API to help in generating three-dimensional balancing diagrams for draglines operating in horizontal and vertical tandem. This graphics program can be adopted for all decision-making situations, such as deciding the bench height for stripping, the width of cut, rate of coal exposure, percentage rehandle, and linear advancement of each dragline in tandem dragline operation. The computer graphics technique has been deployed as a tool to speed up the tedious procedure of manually drawing the balancing diagram, which is not amenable to repeated reiterations. This program can be used to create balancing diagrams for careful analysis and planning of tandem dragline operations. The computer graphics program produces precise and reliable results.

Field studies were conducted on four different mines of Northern Coalfields Ltd., Singarauli, a subsidiary of Coal India Ltd. Different draglines with different modes of operation and under different mining conditions. The draglines had capacities ranging from 10 to 24 m³, cut widths ranging from 70 to 90 m, and stripping bench heights of 27 to 45 m. The modes of operation encountered in the field study were horizontal tandem (in the Jayant, Nighai and Dhudhichua mines), and vertical tandem (in Bina mine).

At the end of this thesis, there is a list of references that were mentioned throughout the thesis. The thesis is approximately 312 pages long and includes figures and appendices.

Keywords: Opencast coal mining, overburden removal, HEMM, dragline, tandem dragline methods, horizontal and vertical tandem, dragline planning in opencast coal mines, pit optimization, software development, three-dimensional balancing diagram, field studies, dragline performance and cost analysis, parametric analysis.