TABLE OF CONTENTS

CONTENTS I

LIST OF FIGURES XI

LIST OF TABLES XV

SYMBOLS XVI

ABSTRACT XVIII

CHAPTER 1

INTRODUCTION

1.1 Introduction 1

1.2 Components of dragline 2

1.3 Dragline bucket 4

1.4 Details of the bucket assembly 5

1.5 Wear of dragline bucket 6

1.6 Static and dynamic loading conditions 7

1.7 Numerical simulation techniques 7

1.8 Statement of the problem 8

1.9 Objective and scope of the study 9

1.10 Research questions 9

1.11 Summary of thesis chapter- wise 10

CHAPTER 2

LITERATURE REVIEW

2.1 Overview of dragline 11

2.2 Productivity factors of the dragline 13
2.3 Dragline productivity studies 15
2.4 Design and filling of excavator bucket 18
2.5 Force impacting the stability of equipment 23
2.5.1 Break out force and penetration effect 23
2.6 Finite element analysis 26
2.6.1 Finite element formulation 26
2.6.2 Steps in FEM 27
2.6.3 Selection of elements 28
2.6.4 Properties of the shape function 29
2.6.5 Applications of FEA 29
2.7 Finite Element Analysis for Earthmoving 30
2.7.1 Basic idea of finite element analysis 30
2.7.2 Applications of finite element analysis in earthmoving equipment 31
2.8 Tool-formation of dragline bucket in earthmoving conditions 33
2.8.1 Cutting resistance model for empirical approaches 34
2.8.2 Cutting resistance model for analytical approaches 35
2.9 Failure analysis criteria 40
2.10 Influence of teeth and rake angle on excavator performance 42
2.11 Summary of the literature review 44

CHAPTER 3

METHODOLOGY

3.1 Research methodology 45
3.2 Field visit 46
3.3 Computerized generation of 3D solid model of dragline bucket 48

3.4 ANSYS workbench with FEA 52

3.5 Steps in static structural analysis in ANSYS 53

3.6 Static loading condition..... 53

3.6.1 Material properties simulated for modelling..... 54

3.6.2 Finite element meshing for static loading 55

3.6.3 Boundary and loading condition for static loading 55

3.7 Boundary and loading condition for hitch elements and arc anchors under static loading conditions..... 57

3.8 Steps in explicit dynamic analysis in ANSYS 57

3.9 Dynamic Loading Condition..... 58

3.9.1 Material property of the model 58

3.9.2 Finite element meshing for dynamic loading..... 58

3.9.3 Boundary and loading condition for dynamic loading..... 59

3.10 Bucket teeth under static loading condition 60

3.10.1 Boundary and loading condition for bucket teeth 60

3.11 Optimisation of rake angle of dragline bucket teeth 61

3.11.1 Overburden material properties..... 62

3.11.2 Input parameters of MATLAB..... 63

3.11.3 Input parameters function for sandstone 64

3.11.4 Input parameters function for shale rock 64

3.12 Simplified block diagram revealing the research design 65

CHAPTER 4

ANALYTICAL COMPUTATIONS TO EVALUATE LOAD, RESISTIVE FORCE AND OPTIMIZATION FUNCTION

4.1 Evaluation of load on bucket under static conditions 66

4.1.1 Empty bucket condition 66

4.1.2 Loaded bucket condition 66

4.2 Evaluation of resistive force in dynamic condition 67

4.3 Determination of optimization function between resistive force and teeth angles..... 71

CHAPTER 5

RESULTS AND DISCUSSIONS

5.1 Construction of dragline bucket 72

5.2 Stress analysis on the dragline bucket 74

5.2.1 Stress analysis on the dragline bucket under static loading condition. 74

(i) Bucket in self- weight condition 74

(ii) Bucket in loaded condition 77

(iii) Bucket in maximum loaded condition 82

5.3 Stress analysis of hitch elements and arc anchors in static loading condition 87

5.3.1 Analysis of hitch elements under bucket loaded condition 88

5.3.2 Analysis of arc anchors under bucket loaded condition 92

5.4 Stress analysis of bucket under dynamic condition 97

5.4.1 Bucket under dynamic condition 97

5.5 Stress analysis of bucket teeth in static condition 100

5.5.1 Bucket teeth under static condition 101

5.6 Comparison of the results between static and dynamic loading condition..... 104

5.7 Optimisation of rake angle of the bucket..... 105

5.7.1 Optimisation of rake angle of the bucket for sandstone material 105

5.7.2 Optimization of rake angle of the bucket for shale rock material 108

5.8 Validation 110

CHAPTER 6

CONCLUSIONS AND RECOMMENDATIONS FOR FUTURE WORK

6.1 Conclusions 112

6.2 Limitations of the study 114

6.3 Recommendations for future work 114

REFERENCES 115

APPENDICES A 122

LIST OF PUBLICATIONS