
Contents

Part I Assembly Line Design Problems

1	Designing Assembly Lines	3
1.1	Introduction	3
1.2	Assembly Line Design	3
1.3	Designing or Optimising?	5
1.4	Layout of the Book	6
2	Design Approaches	7
2.1	Introduction	7
2.2	Why the Design is Difficult?	8
2.3	Design and Search Approaches	8
2.4	The Gap Between Theory and Practice	8
2.4.1	Input Data	9
2.4.2	Multiple Objective Problem	9
2.4.3	Variability	9
2.4.4	Scheduling	9
2.4.5	Layout	10
2.5	About the Quality of a Design	10
2.6	Assembly Line Design Evolution	10
3	Assembly Line: History and Formulation	13
3.1	Introduction	13
3.2	Evolution of Today's Manufacturing Issues	13
3.2.1	First Metals	13
3.2.2	Carpenters and Smiths	13
3.2.3	Cottage Industries	14
3.2.4	Factory System	14
3.2.5	Mass Production	14
3.2.6	Computers in Manufacturing	15
3.3	Assembly Line Systems	15

3.4	Notation and Definitions	16
3.5	Assembly Line Balancing Problems	19
3.5.1	Assembly Line Models	19
3.5.2	Variability of Tasks Process Time	20
3.5.3	Line Configuration	21
3.5.4	Additional Constraints	23
3.5.5	Assembly Line Design Problems	25
3.6	Why is the Balancing Problem Hard to Solve?	27

Part II Evolutionary Combinatorial Optimisation

4	Evolutionary Combinatorial Optimisation.....	31
4.1	Introduction	31
4.2	System Organisation	31
4.3	How Do Genetic Algorithms Work?	32
4.3.1	Representation	33
4.3.2	Initialisation of the Population	34
4.3.3	Sampling Mechanism	35
4.3.4	Genetic Operators	36
4.4	Landscapes and Fitness	38
4.5	Population	38
4.6	Simple... but it Works!	38
5	Multiple Objective Grouping Genetic Algorithm.....	39
5.1	Introduction	39
5.2	Multiple Objective Optimisation	39
5.3	The State of the Art	40
5.3.1	The Use of Aggregating Functions	41
5.3.2	Non-Pareto Approaches	41
5.3.3	Pareto-based Approaches	42
5.3.4	Preferences and Local Search Methods	42
5.3.5	Constrained Problems.....	43
5.4	Grouping Problems and the Grouping Genetic Algorithm.....	44
5.4.1	Encoding Scheme.....	44
5.4.2	Crossover Operator	45
5.4.3	Mutation Operator	46
5.4.4	Inversion Operator	46
5.5	Multiple Objective Grouping Genetic Algorithm.....	46
5.5.1	Control Strategy	47
5.5.2	Individual Construction Algorithm	48
5.5.3	Overall Architecture of the Evolutionary Method	48
5.5.4	Branching on Populations	49
5.6	The Detailed Example	51

Part III Assembly Line Layout

6	Equal Piles for Assembly Line Balancing	59
6.1	Introduction	59
6.2	The State of the Art	59
6.2.1	Exact Methods	59
6.2.2	Approximated Methods	61
6.3	Equal Piles for Assembly Line Balancing	62
6.3.1	Motivation and Inspiration From Nature	63
6.3.2	Input Data	64
6.3.3	Customising the Grouping Genetic Algorithm to the Equal Piles Assembly Line Problem	64
6.3.4	Experimental Results	69
6.4	Extension to Multi-product Assembly Line	71
6.4.1	Multiple Objective Problem	71
6.4.2	Overall Architecture	72
7	The Resource Planning for Assembly Line	77
7.1	Introduction	77
7.2	The State of the Art	78
7.3	Dealing with Real-world Hybrid Assembly Line Design	79
7.3.1	Cost	79
7.3.2	Process Time	80
7.3.3	Availability	82
7.3.4	Station Space	83
7.3.5	Incompatibilities Among Several Types of Equipment ..	84
7.4	Input Data	84
7.5	Overall Method	85
7.5.1	Distributing Tasks Among Stations	85
7.5.2	Selecting Equipment	86
7.5.3	Heuristics	89
7.5.4	Dealing with a Multi-product Assembly Line	90
7.5.5	Complying with Hard Constraints	91
7.6	Application of the Method	92
8	Balance for Operation	93
8.1	Introduction	93
8.2	Multi-product Assembly Line	93
8.3	The State of the Art	94
8.3.1	Classical Methods	94
8.4	Heuristics	95
8.5	Ordering Genetic Algorithm	95
8.5.1	Algorithm	95
8.5.2	Heuristics	97

8.6 Balance for Operation Concept 99
8.6.1 Non-fixed Number of Stations 100
8.6.2 Fixed Number of Stations 102

Part IV The Integrated Method

9 Evolving to Integrate Logical and Physical Layout of Assembly Lines 105
9.1 Introduction 105
9.2 The State of the Art 105
9.3 Assembly Line Design 106
9.4 Integrated Approach 106
9.4.1 Development of the Interactive Method 108
9.4.2 Global Search Phase 115
9.5 Application 116

10 Concurrent Approach to Design Assembly Lines 121
10.1 Introduction 121
10.2 Concurrent Approach 121
10.3 Assembly Line Design 122
10.3.1 Data Preparation Phase 123
10.3.2 Optimisation Phase 124
10.3.3 Mapping Phase 124
10.4 Case Studies 124
10.4.1 Assembly Line Balancing Application: Outboard Motor 125
10.4.2 Resource Planning Application: Car Alternator 128

11 A Real-world Example Optimised by the OptiLine Software 137

12 Conclusions and Future Work 145
12.1 We Attained... 145
12.2 Tendencies and Orientations 145
12.3 Data Collection 146
12.4 Model Formulation 146
12.5 Validation and Output Analysis 146
12.6 The Proposed Approach 147

References 149

Index 159