

Table of Contents

| Content | Page |
|----------------------------|------|
| | No |
| Dedication..... | II |
| Acknowledgements..... | III |
| Abstract..... | IV |
| Abstract in Arabic..... | V |
| Table of Contents..... | VI |
| List of Tables..... | IX |
| List of Figures..... | X |
| List of Abbreviations..... | XII |

Chapter One: Introduction

| | | |
|-----|----------------------------|---|
| 1.1 | Introduction..... | 1 |
| 1.2 | The Problem Statement..... | 6 |
| 1.3 | Scope of this work..... | 6 |

Chapter Two: Literature Review

| | | |
|---------|---|----|
| 2.1 | Line Balancing..... | 7 |
| 2.2 | Methods of Line Balancing..... | 7 |
| 2.2.1 | Heuristic Methods..... | 8 |
| 2.2.1.2 | Largest-Candidate Rule (LCR)..... | 8 |
| 2.2.1.1 | Kilbridge and Wester's Method (KWM)..... | 8 |
| 2.2.1.3 | Ranked Positional Weights Method (RPW)..... | 9 |
| 2.2.2 | Genetic Algorithms..... | 10 |
| 2.2.3 | Simulation..... | 10 |
| 2.3 | Time Study | 10 |
| 2.4 | Previous Works | 11 |

| | | |
|-----|------------------------------|----|
| 2.5 | Objectives of This Work..... | 18 |
|-----|------------------------------|----|

Chapter three: Materials and Methods

| | | |
|-------|--|----|
| 3.1 | Introduction..... | 19 |
| 3.2 | Overview of the Company..... | 19 |
| 3.2.1 | Types of Products..... | 20 |
| 3.3 | Case Study Selected Product..... | 20 |
| 3.4 | Garment Manufacturing Process..... | 23 |
| 3.5 | Production process of the Company..... | 24 |
| 3.5.1 | Fabric spreading..... | 24 |
| 3.5.2 | Cutting..... | 24 |
| 3.5.3 | Numbering..... | 25 |
| 3.5.4 | Sorting out of Pieces..... | 25 |
| 3.6 | Manufacturing of U3 Long Sleeve Shirt..... | 25 |
| 3.6.1 | The Preparation of U3 Shirt..... | 25 |
| 3.6.2 | Assembly of U3 Shirt..... | 26 |
| 3.6.3 | Finishing operations..... | 28 |
| 3.7 | Simulation Tools and Parameters | 29 |
| 3.7.1 | Simulation Parameters..... | 30 |
| 3.7.2 | Module Architecture and Design..... | 30 |
| 3.7.3 | Tools and Technologies..... | 31 |
| 3.8 | Model Development Steps | 32 |
| 3.8.1 | Model user login..... | 32 |
| 3.8.2 | Initialization and Parameter Settings..... | 33 |
| 3.8.3 | Cases Simulation Screen..... | 33 |
| 3.9 | Algorithm..... | 36 |

Chapter four: Results and Analysis

| | | |
|-------|---|----|
| 4.1 | Collected data analysis..... | 39 |
| 4.2.1 | Sample Calculations of the waiting time and finish time on U3 Shirt assembly line. | 40 |
| 4.3 | Simulation Results and Analysis..... | 50 |
| 4.3.1 | Result based on real system..... | 50 |
| 4.3.2 | Result based on Alternative Scenario1..... | 51 |
| 4.3.3 | Result based on Alternative Scenario2..... | 53 |
| 4.3.4 | Result based on Alternative Scenario3..... | 56 |

Chapter five: Conclusions and Recommendations

| | | |
|-----|----------------------|-----|
| 5.1 | Conclusions..... | 62 |
| 5.2 | Recommendations..... | 63 |
| | References..... | 64 |
| | Appendix A..... | 69 |
| | Appendix B..... | 72 |
| | Appendix C..... | 101 |

List of Tables

| Table No. | Title | Page No |
|------------------|--|----------------|
| 3.1 | Operations code name of U3 Shirt | 23 |
| 4.1 | U3 shirt Assembly line average time..... | 40 |
| 5.1 | Simulation details and results..... | 59 |

List of Figures

| Figure No. | Title | Page No |
|------------|--|------------|
| 1.1 | Assembly Lines for Single and Multiple Products (Becker and Scholl, 2003) | 3 |
| 1.2 | Assembly line workstations..... | 5 |
| 3.1 | SUR Shareholding Structure..... | 19 |
| 3.2 | U3 Long Sleeve Shirt model..... | 21 |
| 3.3 | Operations Flowchart of U3 Shirt..... | 22 |
| 3.4 | Preparation line flow chart..... | 27 |
| 3.5 | Assembly section flow chart..... | 28 |
| 3.6 | Finishing section flow chart..... | 29 |
| 3.7 | Model architecture and design..... | 30 |
| 3.8 | Login form screen..... | 32 |
| 3.9 | Settings screen..... | 33 |
| 3.10 | Cases Simulation..... | 34 |
| 3.11 | Create New Record..... | 34 |
| 3.12 | Cases Simulation result..... | 35 |
| 4.1 | average cycle time (s) graph for performing the operation to make a U3 shirt | 39 |
| 4.2 | Waiting and finish time Calculation Sample..... | 49 |
| 4.3 | Real system simulation screenshot..... | 50 |
| 4.4 | Alternative Scenario1 screenshot..... | 51 |
| 4.5 | Alternative Scenario1 finish time line graph..... | 52 |
| 4.6 | Alternative Scenario1 finish time bar graph..... | 52 |
| 4.7 | Alternative Scenario1 waiting time line graph..... | 53 |
| 4.8 | Alternative Scenario1 waiting time bar graph..... | 53 |

| | | |
|------|--|----|
| 4.9 | Alternative Scenario2 screenshot..... | 54 |
| 4.10 | Alternative Scenario2 finish time line graph..... | 54 |
| 4.11 | Alternative Scenario2 finish time bar graph..... | 55 |
| 4.12 | Alternative Scenario2 waiting time line graph..... | 55 |
| 4.13 | Alternative Scenario2 waiting time Bar graph..... | 56 |
| 4.14 | Alternative Scenario3 screenshot..... | 57 |
| 4.15 | Alternative Scenario3 finish time line graph..... | 57 |
| 4.16 | Alternative Scenario3 finish time bar graph..... | 58 |
| 4.17 | Alternative Scenario3 waiting time line graph..... | 58 |
| 4.18 | Alternative Scenario3 waiting time bar graph..... | 59 |

List of Abbreviations

| Abbreviations | Full Meaning of Abbreviations |
|---------------|---------------------------------|
| ALB | Assembly Line Balancing |
| ALBP | Assembly Line Balancing Problem |
| LCR | Largest Candidate Rule |
| KWM | Kilbridge and Wester Method |
| RPW | Ranked Positional Weights |
| SMV | Standard Minute Value |
| LM | Lean Manufacturing |
| GUI | Graphical User Interface |
| SQL | Structured Query Language |
| HTML | Hyper Text Markup Language |
| CSS | Cascades Style Sheets |
| HTTP | Hyper Text Transport Protocol |