

**A NEW PRODUCT IMPLEMENTATION MODEL FOR  
THE PNEUMATIC TYRE MANUFACTURING  
PROCESS**

Lasantha Harshana Munasinghe

09/8608



University of Moratuwa, Sri Lanka.  
Electronic Theses & Dissertations  
[www.lib.mrt.ac.lk](http://www.lib.mrt.ac.lk)

MEng in Manufacturing System Engineering

Department of Mechanical Engineering

University of Moratuwa

June 2015

**A NEW PRODUCT IMPLEMENTATION MODEL FOR  
THE PNEUMATIC TYRE MANUFACTURING  
PROCESS**

Lasantha Harshana Munasinghe

09/8608



University of Moratuwa, Sri Lanka.  
Electronic Theses & Dissertations  
[www.lib.mrt.ac.lk](http://www.lib.mrt.ac.lk)

Dissertation submitted in partial fulfillment of the requirements for the degree  
Master of Engineering

Department of Mechanical Engineering

University of Moratuwa

June 2015

## DECLARATION

I declare that this is my own work and this dissertation does not incorporate without acknowledgement any material previously submitted for a Degree or Diploma in any other University or institute of higher learning and to the best of my knowledge and belief, it does not contain any material previously published or written by another person except where the acknowledgement is made in the text.

Also, I hereby grant to University of Moratuwa the non-exclusive right to reproduce and distribute my dissertation, in whole or in part in print, electronic or other medium. I retain the right to use this content in whole or part in future works (such as articles or books).

Signature:

Date:

 The above candidate has carried out research for the Masters Dissertation under my supervision.

University of Moratuwa, Sri Lanka.  
Electronic Theses & Dissertations  
[www.lib.mrt.ac.lk](http://www.lib.mrt.ac.lk)

Signature of the supervisor:

Date

## Abstract

Pneumatic tyre manufactures face the problems related to the life cycle of products at product launching stage. In an effort to improve timeliness and effectiveness, pneumatic tyre industry is experimenting with different best practices in their new product implementation processes.

This research aims to develop a model for new product implementation for pneumatic tyre industry using a framework based on quality function deployment (QFD). It supports the development of customer focused, agile products and to meet customer expectations in terms of innovation and customisation, quality and competitive price.

During this research, new product implementation models were studied. Some issues of existing new product introduction processes were discussed and new product implementation model was proposed based on the literature, and case studies were used to support the development of the model. A QFD structure was introduced to identify relationships between product design factors and issues of each sub process. These relations were described as weak, moderate and strong. Then the proposed model was validated using case studies.

When the proposed model is applied to the new tyre development, communication path of all relevant parties strengthened by four times, new product implementation time reduced by 20 percent and cost of implementation reduced by 30 percent. In this new model issues can be identified at the product design stage.

This model can be modified to use for new product implementations of any other product. This system can also be modified using computerized system with artificial intelligence to make it more attractive to the users.



## ACKNOWLEDGEMENTS

I would like to express my gratitude to my supervisor Dr. Himan K.G. Punchihewa for the useful comments, remarks and engagement through the learning process of this master thesis. Also, I like to thank the participants in my survey, who have willingly shared their precious time during the process of interviewing. I would like to thank my loved ones, who have supported me throughout the entire process, both by keeping me harmonious and helping me putting the pieces together.



University of Moratuwa, Sri Lanka.  
Electronic Theses & Dissertations  
[www.lib.mrt.ac.lk](http://www.lib.mrt.ac.lk)

Declaration.....	i
Abstract.....	ii
Acknowledgements.....	iii
List of figures.....	viii
List of tables.....	ix
List of abbreviations.....	xiii
Chapter 1 Introduction.....	1
1.1 Research Rationale.....	1
1.2. Aim:.....	2
1.3. Objectives:.....	2
1.4. Methodology.....	2
Chapter 2 literature Review.....	4
2.1. Introduction.....	4
2.2. Existing New Product Implementation Models.....	4
2.2.1. Concurrent engineering model.....	7
2.2.2. Phase and stage gate model.....	10
2.2.3. Booz, Allen and Hamilton’s new product development process.....	11
2.3. New Product Implementation Tools.....	16
2.3.1. Quality function deployment (QFD).....	16
2.3.2. Taguchi method.....	18
2.3.3. Statistical process control (SPC).....	19
2.3.4. Value analysis or Value engineering (VA/VE).....	20
2.3.5. Failure modes and effects analysis (FMEA).....	21
2.3.6. Lean manufacturing.....	23
2.4. New Products Failures.....	24
2.4.1. Examples for new product implementation failures.....	26
2.4.2. Failure factors.....	28



University of Moratuwa, Sri Lanka.  
 Electronic Theses & Dissertations  
[www.lib.mrt.ac.lk](http://www.lib.mrt.ac.lk)

2.5. Summary .....	29
Chapter 3 Bottleneck identification .....	32
3.1. Introduction .....	32
3.2. Pneumatic Tyre Manufacturing Process .....	32
3.3. Product Design.....	34
3.3.1 Tire components.....	35
3.4. Prototype Making .....	37
3.5. Product Testing.....	40
3.6. Pilot Production .....	41
3.7. Mass Production .....	43
3.8. Case Study 1: Product Name AB-X SD ED PLUS .....	43
3.8.1. Timeline for implementation.....	47
3.9. Case Study 2: Product Name CD-Y 28PR HA LT.....	47
3.9.1. Timeline for implementation.....	49
Table 3.3 shows the time line for implementation product of CD-Y HALT ....	49
3.10 Summary of New Product Implementation in History .....	50
3.11. Issues of Existing Model.....	51
Chapter4 Model for new product implementation.....	54
4.1 Introduction .....	54
4.2 Proposed Model.....	54
4.3. Technical Feasibility.....	57
4.3.1. Carcass building operation.....	58
4.3.2. Bead preparation process .....	58
4.3.3. Layer, inner liner and side wall preparation process.....	59
4.3.4. Tread rolling process .....	59
4.3.5. Tyre curing operation .....	59
4.3.4. Financial analysis .....	60
4.4. Benchmarking.....	60

4.5. Barrier Identification.....	62
4.6. Five Products Test .....	64
4.7. Ten Products Test .....	68
4.8. Pilot production .....	72
Chapter 5 model validation.....	73
5.1 Introduction .....	73
5.2 Case Study 1: New Product IJ-K HA SKS 730.....	73
5.2.1. Design the new product .....	73
5.2.2. Technical feasibility .....	75
5.2.3. Benchmarking .....	78
5.2.4. Barrier identification.....	80
5.2.5. Five product test .....	95
5.2.6. Ten product test.....	95
5.2.7. Pilot production.....	95
5.2.8. Timeline for implementation.....	96
5.2.9. Cost comparison of implementation.....	96
5.3. Case Study 2: New Product Name EM-N 10PR HA SKS 775 .....	97
5.3.1 Design the new product .....	97
5.3.2. Technical feasibility.....	99
5.3.3. Benchmarking .....	102
5.3.4. Barrier identification.....	103
Carcass building operation .....	103
5.2.5. Five product test .....	118
5.2.6. Ten product test.....	118
5.2.7. Pilot production.....	118
5.2.8. Timeline for implementation.....	119
5.2.9. Cost comparison of implementation.....	119
Chapter 6 conclusion and reccomendation.....	120





6.1 Discussion .....	120
6.2. Conclusion.....	123
6.3 Further Work .....	124
References.....	125
Appendix 1 questionnaires for Carcass building operation.....	128
Appendix 2 questionnaires for Bead preparation process .....	130
Appendix 3 questionnaires for Layer and liner preparation process .....	132
Appendix 4 questionnaires for tread rolling process.....	134
Appendix 5 questionnaires for curing process.....	136



University of Moratuwa, Sri Lanka.  
Electronic Theses & Dissertations  
[www.lib.mrt.ac.lk](http://www.lib.mrt.ac.lk)

## LIST OF FIGURES

Figure 2.1 Myers and Marquis’ model.....	5
Figure 2.2 JM Utterback’ model.....	6
Figure 2.3 New product implementation based concurrent model.....	8
Figure 2.4 The Phase and Stage Gate Model.....	10
Figure 2.5 Booz, Allen and Hamilton’s new product development process.....	11
Figure 2.6 The gates of the Phase and Stage Gate Model.....	13
Figure 2.7 Comparison between QFD and traditional method.....	17
Figure 3.1 Pneumatic tyre manufacturing process.....	32
Figure 3.2 Existing new product implementation model.....	33
Figure 3.3 Cross section of pneumatic tyre.....	34
Figure 3.4 Prototype making process.....	39
Figure 3.5 Product testing process.....	41
Figure 3.6 Tread pattern differences in AB-X.....	44
Figure 3.7 Number of LLT defect tyres in AB-X SD ED PLUS.....	45
Figure 3.8 Defect percentages of LLT defect tyres in AB-X SD ED PLUS.....	45
Figure 3.9 Percentage of SWSW defect tyres in AB-X SD ED PLUS.....	46
Figure 3.10 Percentage of thin bead defect tyres in CD-Y HA LT.....	48
Figure 3.11 Percentage of thin bead defect tyres in CD-Y HA LT.....	49
Figure 4.1 QFT model for new product implementation.....	56
Figure 4.2 Quality defects of product AA and number of tyres.....	65
Figure 4.3 Quality defects of product AB and number of tyres.....	67
Figure 4.4 Quality defects of product AC and number of tyres.....	68
Figure 4.5 wastage of inner liner in product AA.....	70
Figure 4.6 wastage of layers in product AA.....	70
Figure 4.7 wastage of inner liner in product AB.....	71
Figure 4.8 wastage of layers in product AB.....	72
Figure 5.1 defect percentage of IJ-K sizes.....	93
Figure 5.2 defect percentage of LM-N sizes.....	116

## LIST OF TABLES

Table 2.1 New product success rates .....	24
Table 3.1 involving sections for prototype making process.....	40
Table 3.2 Timeline for implementation of AB-X SD PLUS .....	47
Table 3.3 Time line for implementation of CD-Y HA LT .....	49
Table 3.4(A) Issues of implemented new products in history .....	50
Table 3.4(B) Issues of implemented new products in history .....	51
Table 3.5 Cost of scrap and 2 <sup>nd</sup> choice products during new product implementing on October .....	53
Table 4.1 Technical feasibility study for carcass building operation.....	58
Table 4.2 Technical feasibility study for bead preparation process.....	58
Table 4.3 Technical feasibility study for calendar machine process .....	59
Table 4.4 Technical feasibility study for tread rolling process .....	59
Table 4.5 Technical feasibility study for tyre curing operation.....	59
Table 4.6 Technical feasibility study for financial.....	60
Table 4.7 Selecting benchmarking product.....	61
Table 4.8 identifying the issues in each sub process.....	62
Table 4.9 Format for QFD based model.....	63
Table 4.10 Values for relationship factors.....	64
Table 4.11 Quality defects of product AA .....	65
Table 4.12 Quality defects of product AB.....	66
Table 4.13 Quality defect of product AC .....	67
Table 4.14 wastage of materials in product AA .....	69
Table 4.15 wastage of materials in product AB.....	71
Table 4.16 wastage of materials in product AC.....	72
Table 5.1 Product parameters of IJ-KHA SKS 730 .....	73
Table 5.2 Proposed product specification of IJ-K HA SKS 730 .....	74

Table 5.3 Technical feasibility study for carcass building operation of IJ-K HA SKS 730.....	75
Table 5.4 Technical feasibility study for bead preparation of IJ-K HA SKS 730....	75
Table 5.5 Technical feasibility study for calendar machine process- IJ-K HA SKS 730.....	76
Table 5.6 Technical feasibility study for tread rolling operation of IJ-K HA SKS 730 .....	76
Table 5.7 Technical feasibility study for tyre curing operation of IJ-K HA SKS 730 .....	77
Table 5.8 Technical feasibility study for financial analyse of IJ-K HA SKS 730....	77
Table 5.9 Benchmarking product in bead operation- IJ-K 12PR HA SKS 730 .....	78
Table 5.10 Benchmarking product in bead operation- IJ-K 12PR HA SKS 730 .....	78
Table 5.11 Benchmarking products in layer preparation- IJ-K 12PR HA SKS 730	79
Table 5.12 Benchmarking products in sidewall preparation- IJ-K 12PR HA SKS 730 .....	79
Table 5.13 Benchmarking products in IL preparation- IJ-K 12PR HA SKS 730 ....	79
Table 5.14 Benchmarking products in IL preparation- IJ-K 12PR HA SKS 730 ....	80
Table 5.15 Summarised results of questioners in Carcass building operation- IJ-K 12PR HA SKS 730 .....	81
Table 5.16 (C) QFD based model carcass building operation- IJ-K 12PR HA SKS 730.....	84
Table 5.17 Results of questioners in bead preparation process- IJ-K 12PR HA SKS 730.....	85
Table 5.18 QFD based model bead preparation process- IJ-K 12PR HA SKS 730 .	86
Table 5.19 Summarized results of questioners in layer and inner liner preparation process- IJ-K 12PR HA SKS 730 .....	87
Table 5.20 QFD based model layer and inner liner preparation process- IJ-K 12PR HA SKS 730 .....	88
Table 5.21 Summarised results of questioners in tread rolling process- IJ-K 12PR HA SKS 730 .....	89
Table 5.22 (A) QFD based model tread rolling process- IJ-K 12PR HA SKS 730..	90
Table 5.22(B) QFD based model tread rolling process- IJ-K 12PR HA SKS 730...	90

Table 5.23 Summarized results of questioners in curing process- IJ-K 12PR HA SKS 730.....	91
Table 5.24 QFD based model tyre curing process- IJ-K 12PR HA SKS 730 .....	92
Table 5.25 QFD based model quality issues- IJ-K 12PR HA SKS 730.....	94
Table 5.26 Timeline for implementation of IJ-K HA SKS 730.....	96
Table 5.27 Cost comparison of IJ-K HA SKS 730 implementations .....	97
Table 5.28 Product parameters of LM-N HA SKS 775 .....	97
Table 5.29 Proposed product specification of LM-N HA SKS 775 .....	98
Table 5.30 Technical feasibility study for carcass building operation of LM-N HA SKS 775.....	99
Table 5.31 Technical feasibility study for bead preparation of LM-N HA SKS 775.....	99
Table 5.32 Technical feasibility study for calendar machine process- LM-N HA SKS 775.....	100
Table 5.33 Technical feasibility study for tread rolling operation of LM-N HA SKS 775.....	100
Table 5.34 Technical feasibility study for tyre curing operation of LM-N HA SKS 775.....	101
Table 5.35 Technical feasibility study for financial analyse of LM-N HA SKS 775 .....	101
Table 5.36 Benchmarking product in bead operation- LM-N HA SKS 775.....	102
Table 5.37 Benchmarking product in bead operation- LM-N 10PR HA SKS 775 .....	102
Table 5.38 Benchmarking products in layer preparation- LM-N 10PR HA SKS775 .....	102
Table 5.39 Benchmarking products in sidewall preparation- LM-N 10PR HA SKS775 .....	103
Table 5.40 Benchmarking products in IL preparation- LM-N 10PR HA SKS 775 .....	103
Table 5.41 Benchmarking products in IL preparation- LM-N 10PR HA SKS 775 .....	103
Table 5.42 Summarised results of questioners in Carcass building operation- LM-N 10PR HA SKS 775 .....	104
Table 5.43 (A) QFD based model carcass building operation- LM-N 10PR HA SKS 775.....	105



Table 5.43(B) QFD based model carcass building operation- LM-N 10PR HA SKS 775.....	106
Table 5.43(C) QFD based model carcass building operation- LM-N 10PR HA SKS 775.....	107
Table 5.44 Summarised results of questioners in bead preparation process- LM-N 10PR HA SKS 775 .....	108
Table 5.45 QFD based model bead preparation process- LM-N 10PR HA SKS775 .....	109
Table 5.46 Summarised results of questioners in layer and inner liner preparation process- LM-N 10PR HA SKS 775 .....	110
Table 5.47 QFD based model layer and inner liner preparation process- LM-N 10PR HA SKS 775 .....	111
Table 5.48 Summarised results of questioners in tread rolling process- LM-N 10PR HA SKS 775 .....	112
Table 5.49 QFD based model tread rolling process- LM-N 10PR HA SKS 775 ...	113
Table 5.50 Summarised results of questioners in curing process- LM-N 10PR HA SKS 775.....	114
Table 5.51(A) QFD based model tyre curing process- LM-N 10PR HA SKS 775	115
Table 5.51(B) QFD based model tyre curing process- LM-N 10PR HA SKS 775	115
Table 5.52 QFD based model quality issues- LM-N 10PR HA SKS 775.....	117
Table 5.53 Time line for implementation of LM-N HA SKS 775.....	119
Table 5.54 Cost comparison of LM-N HA SKS 775 implementations .....	119



## LIST OF ABBREVIATIONS

CE - Concurrent Engineering

FMEA - Failure Mode Effect Analysis

FFE - Fuzzy Front End

QFD - Quality Function Deployment

HOQ - House of Quality

SPC - Statistical Process Control

VA/VE -Value Analysis or Value Engineering

JIT -Just-In-Time

LLT -Less Liner Thickness

QC - Quality Checkers

SM SW - Short Mould on Sidewall

OD – Outer Diameter



University of Moratuwa, Sri Lanka.

Electronic Theses & Dissertations

[www.lib.mrt.ac.lk](http://www.lib.mrt.ac.lk)