

LB/DON/57/08

CRITICAL EVALUATION OF CONTAINER TRAILER FAILURES AND IMPROVEMENTS IN THEIR MANUFACTURE

A dissertation submitted to the
Department of Mechanical Engineering, University of Moratuwa
in partial fulfillment of the requirements for the
Degree of Master of Engineering

LIBRARY
UNIVERSITY OF MORATUWA, SRI LANKA
MORATUWA



University of Moratuwa, Sri Lanka.
Electronic Theses & Dissertations
www.lib.mrt.ac.lk

SIVAYOGANATHAN MUGUNTHAN

Supervised by Dr. M. A. R. V. Fernando

University of Moratuwa



91214

91214

**Department of Mechanical Engineering
University of Moratuwa
Sri Lanka**

October 2007

91214

DECLARATION

The work submitted in this dissertation is the result of my own investigation, except where otherwise stated.

It has not already been accepted for any degree, and is also not being concurrently submitted for any other degree.

UOM Verified Signature

S. Mugūnthan

Date 01/10/2007



University of Moratuwa, Sri Lanka.
Electronic Theses & Dissertations
www.lib.mrt.ac.lk

I endorse the declaration by the candidate.

UOM Verified Signature

Dr. M. A\ R. V\ Fernando

Abstract

Container trailer manufacturing is a growing industry in Sri Lanka. Only two organizations are involved in this business and the monthly production was recorded as 100 to 125 trailers. Like other manufacturing industries, trailer industry also faces problems due to trailer failures and difficulties to improve the trade. Failures are mainly due to lack of design stage analysis of the product. The primary objective of my research project is to analyze trailer failure problems and suggest solutions to improve the trailer industry in Sri Lanka.

The methodology of this research is a combination of research training programme, questionnaire based study and a finite element analysis of the trailer solid model. Research training programme was arranged in a leading manufacturing and servicing organization in Sri Lanka by the Department of Mechanical Engineering, University of Moratuwa. It was very useful to understand the trailer manufacturing concepts, designs, trailer failures and the general problems faced by the trailer industry.

Questionnaires are produced to two different categories of industries such as Trailer manufacturers and Trailer users. Questionnaires for trailer manufacturers are oriented towards identifying the techniques used by manufacturers to control the failures especially in design stage and identifying their problems and limitations in manufacturing trailers. Questionnaires for trailer users are oriented towards identifying trailer failures.

A finite element analysis was carried out to study the present design of a particular type of trailer to identify the efficiency in design and to present any solutions if needed. Further, there were several rounds of semi-structured interviews with technical specialists, designers, supervisors and welders who were involved in trailer manufacturing. By the combination of all the efforts, it is found that trailer failures are mainly due to the problems due to design, fabrication, materials and parts selection, human resource and trailer misuse. Suggestions to present trailer problems and future improvements in trailer manufacture are produced.

Acknowledgement

It has been great pleasure to devote my valuable time on a pioneering effort like this and to acknowledge all professionals who contribute their time for my research project. Their untiring support made this project a reality and a very successful achievement.

Thanks are due first to my supervisor, Dr. M. A. R. V. Fernando, Department of Mechanical Engineering, for his great insights, perspectives, guidance and sense of humor.

A very special gratitude goes to Dr. G. K. Watugala, Department of Mechanical Engineering, for all encouragements and guidance given especially in this project.

I also extend my sincere gratitude to Mr. H. Athula, Director, Tantri Trailer Manufacturers (Pvt) Ltd., Mr Howard Smith, Technical Specialist, Dutch Lanka Trailer Manufacturers (Pvt) Ltd. and Mr Bastian Molenaar, Technical Director, Dutch Lanka Trailer Manufacturers (Pvt) Ltd. for their technical assistance and further, all other industrialists and trailer users, who sacrifice their time and effort to make this project success.



University of Moratuwa, Sri Lanka.
Electronic Theses & Dissertations
www.lib.mrt.ac.lk

Lastly, I should thank my parents, wife, friends and colleagues who have not been mentioned here personally in making this educational process a success. May be I could not have made it without your supports.

Sivayoganathan Mugunthan

October 2007

Table of contents

Title	i
Declaration	ii
Abstract	iii
Acknowledge	iv
List of contents	v
CHAPTER 1- Introduction	1
1.1 Background of the problem	1
1.2 The scope of the study and definition of the problem	1
1.3 Research objectives	2
1.4 Review of previous research	3
CHAPTER 2- Literature Survey	4
2.1 What are container trailers	4
2.2 Types of container trailers manufactured in Sri Lanka	4
2.3 Other types of trailers manufactured in Sri Lanka	5
2.4 Specifications of trailers manufactured in Sri Lanka	6
2.4.1 Terminal trailer specification	6
2.4.2 Curtain side trailer specification	7
2.4.3 Tipper trailer specification	8
2.4.4 Tanker trailer specification	9
2.5 Key parts of a trailer	10
2.6 Trailer manufacturing procedure	16
2.7 Inspection and testing	19
2.7.1 Inspection and test procedure followed at the factory	19
2.7.2 Inspection and test procedure followed at the project site	19
2.8 Failure	21
2.8.1 Failure analysis	21
2.8.2 Failure analysis procedure	22

2.8.3 Objectives of the failure analysis	22
2.8.4 Root cause analysis procedure	22
2.8.5 Preventing a failure	23
2.9 Methods used in the failure analysis	23
2.9.1 Finite element analysis	24
2.9.2 Computer aided design and Finite element analysis	26
2.9.3 Current FEA trends in the trailer industry	26
2.10 Introduction to FEA software	27
2.10.1 ABAQUS	27
2.10.2 COSMOS/ DesignSTAR	27
2.10.3 COSMOS/Motion	27
2.10.4 J L Analyzer/ Auto FEA	28
2.10.5 ANSYS	28
2.10.6 Pro/MECHANICA	28
CHAPTER 3- Research Methodology	29
3.1 Introduction	29
3.2 Methodology	30
CHAPTER 4- Research training programme and the outcomes	31
4.1 Manufacturing site	31
4.2 Repair and service site	33
4.3 Failures identified and the remedies taken	33
4.4 Cracks observed	39
CHAPTER 5- Finite element analysis of the 40 feet flat bed trailer	40
5.1 Introduction	40
5.2 Procedure followed for FEA	40
5.3 COSMOS/Works	40
5.4 FEA using COSMOS/Works	41



5.5 Boundary loading conditions and finite element mesh on model	42
5.6 Results obtained in FEA	43
5.6.1 Analysis 1 – Trailer fixed on two points (Normal stage)	43
5.6.2 Analysis 2 – Trailer fixed on one point (Special and critical stage)	44

CHAPTER 6- Investigation of Problematic Issues and the Suggested Solutions

for Future Plans 46

6.1 Introduction	46
6.2 Problems and suggested solutions	46
6.2.1 Design problem	46
6.2.2 Fabrication problem	49
6.2.3 Materials and parts selection problem	50
6.2.4 Testing and inspection problem	54
6.2.5 Human resource problem	54
6.2.6 Trailer misuse problem	55

CHAPTER 7- Conclusions

7.1 Overview	57
7.2 Problematic issues and solutions of trailer manufacturing	57
7.2.1 Poor design/ Lack of design stage analysis of trailer	57
7.2.2 Insufficient knowledge of designers	58
7.2.3 Poor materials and parts selection	58
7.2.4 Insufficient testing facility	59
7.2.5 Not standardized manufacturing methods	59
7.2.6 Welders turnover	60
7.2.7 Poor highways	60
7.2.8 Misuse of trailer	61
7.3 Further research topics in trailer manufacture	61

REFERENCES	62
-------------------	----

List of Figures

Figure 2.1	Bomb cart / Terminal trailers	4
Figure 2.2	Low bed trailers	4
Figure 2.3	Skeletal and flat bed trailers	4
Figure 2.4	Semi trailers	5
Figure 2.5	Curtain side trailers	5
Figure 2.6	Fuel Tanker / Cement trailer	5
Figure 2.7	Tipper trailers	5
Figure 2.8	Diagram of terminal trailer	6
Figure 2.9	Diagram of curtain side trailer	7
Figure 2.10	Diagram of tipper trailer	8
Figure 2.11	Axle	11
Figure 2.12	Bogie suspension unit	12
Figure 2.13	Combination suspension unit	12
Figure 2.14	Air suspension unit	13
Figure 2.15	Hydro pneumatic suspension unit	13
Figure 2.16	Torsion bar suspension unit	14
Figure 2.17	Rubber suspension unit	14
Figure 2.18	King pin joint	15
Figure 2.19	Landing leg	15
Figure 2.20	Twist Lock	15
Figure 2.21	Trailer manufacturing procedure	16
Figure 2.22	Stages of manufacture of gooseneck	17
Figure 2.23	Slots on main beam for cross members	17
Figure 3.1	Methodology	30
Figure 4.1	Gooseneck preparation	31
Figure 4.2	Gooseneck preparation	31
Figure 4.3	Part of fabricated gooseneck	31

Figure 4.4	Welding of flat bed trailer	31
Figure 4.5	Fabrication of suspension hanger	32
Figure 4.6	Painting of trailer	32
Figure 4.7	Fabrication of stiffeners and gussets plates	32
Figure 4.8	Fabrication of cross – beams	32
Figure 4.9	Part of the fabrication section	32
Figure 4.10	Fabricated trailer being tested by a prime mover	32
Figure 4.11	Repair of I-beam crack	33
Figure 4.12	Landing legs being replaced	33
Figure 4.13	Cross beam bending	33
Figure 4.14	After repaired	33
Figure 4.15	Modification of gusset plate	34
Figure 4.16	Modification of gooseneck welding	34
Figure 4.17	Force flow diagram of initial gooseneck design	35
Figure 4.18	Force flow diagram of modified gooseneck design	35
Figure 4.19	Previous kingpin plate welding	36
Figure 4.20	Modified kingpin plate welding	36
Figure 4.21	Stiffeners	37
Figure 4.22	Concentrated loading and distributed loading	38
Figure 4.23	Misalignment of trailer and prime mover	38
Figure 4.24	Crack generated close to extra tyre hanger	39
Figure 4.25	Crack between suspension hangers and gooseneck	39
Figure 4.26	Cracks above suspension hangers	39
Figure 4.27	Crack along landing leg joint	39
Figure 5.1	40 feet flat bed trailer	41
Figure 5.2	Modified solid model of the trailer	42
Figure 5.3	Boundary loading conditions of analysis	42
Figure 5.4	Displacement diagram	43
Figure 5.5	Strain diagram	43
Figure 5.6	Stress diagram	44
Figure 5.7	Displacement diagram	44

Figure 5.8	Strain diagram	45
Figure 5.9	Stress diagram	45
Figure 6.1	Suggested design	47
Figure 6.2	FEA stress diagram	48
Figure 6.3	Manual stress calculations	49
Figure 6.4	Bolted King pin	51
Figure 6.5	Welded King pin	51
Figure 6.6	Kingpin joint	51
Figure 6.7	Assembled bolted kingpin	51
Figure 6.8	Main (I) beam with voids	53
Figure 6.9	Manufacture of castellated beam	53

List of Tables

Table 2.1	Terminal trailer specification	6
Table 2.2	Curtain side trailer specification	7
Table 2.3	Tipper trailer specification	8
Table 2.4	Tanker trailer specification	9
Table 2.5	Application of trailers	10
Table 2.6	Painting of trailers	18
Table 6.1	Kingpins	52

Abbreviations

CAD	Computer Aided Design
FCAW	Flux Cored Arc Welding
FEA	Finite Element Analysis
HAZ	Heat Affected Zone
MAG	Metal Active Gas welding
MMAW	Manual Metal Arc Welding