

LB/DON/28/10

DESIGN OF A GARBAGE COMPACTING TRACTOR TRAILER BODY DESIGN

LIBRARY
UNIVERSITY OF MORATUWA, SRI LANKA
MORATUWA

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

in Manufacturing
Systems Engineering

By

A. WIJESINGHE

Supervised by

Dr. M. A. R. V. Fernando

621 "08"

621.7(043)

TH

Department of Mechanical Engineering

University of Moratuwa

University of Moratuwa



93934

Sri Lanka

93934

December 2008

93934

DECLARATION

This Dissertation paper contains no material which has been accepted for the award of any other degree or diploma in any University or equivalent institution in Sri Lanka or abroad, and that to the best of my knowledge and belief, contains no material previously published or written by any other person, except where due reference is made in the text of this Dissertation.

I carried out the work described in this Dissertation under the supervision of Dr. M. A. R. V. Fernando

Signature : *UOM Verified Signature* Date : 18-03-2009

Name of Student : A. Wijesinghe

Registration No : 04/8643

Signature : *UOM Verified Signature*

Date : 19-03-2009

Name of Supervisor : Dr. M. A. R. V. Fernando



ABSTRACT

Sri Lanka local government authorities commonly use four wheel tractor trailers for collection and transportation of Municipal solid waste collected daily. There are many environmental issues in using open tractor such as bad smell, over spillage of garbage, risk of diseases etc. In addition tractor trailers are frequently damaged while unloading at uneven surfaces in dumping yards.

The fully covered compactors are available at Colombo Municipal Council and several other local government authorities in Sri Lanka. Most of them have been received under foreign aid. They are sophisticated vehicles and convenient for garbage collection activities. It can transport higher load safely and without having environmental consequences stated above. There are several types of compactors available in the world such as front loading, rear loading and side loading compactors. In Sri Lanka, rear loading compactors are commonly used.

This project aims to manufacture garbage compacting unit which can be mounted on the tractor trailer. The compactor will be rear loading, closed type body with hydraulic compacting system. The available pump of the tractor is used for the hydraulic circuit. Several experiments were carried out to get loads and other measurements required for the design.

The body made out of steel sheets and U-channels available in the local market and hydraulic components have to be obtained from its local suppliers.

Manual calculations and computer software packages of "SolidWorks" and "COSMOSWorks" were used for the design of the compactor body. Total cost for this modification is estimated to Rs 1,000,000/=. It is rather low cost compared to the performance of the imported compactors.

ACKNOWLEDGEMENTS

I wish to express my sincere gratitude to the Mechanical Engineering Department of the University of Moratuwa, Sri Lanka for giving me the opportunity to participate in the Master in Manufacturing Engineering Design Course. During this course I was able to expand my knowledge and practical skills in manufacturing engineering while improving other aspects such as presentation skills, academic writing abilities etc. I enjoyed my return to the university as a post-graduate student.

I am also grateful to all the lecturers and mentors of the course for all the guidance given to at all times. I am very thankful to all but especially to the course coordinator Dr. G. K. Watugala, Dr. Udaya Kahangamage, Dr. T. A. Piyasiri and Mr. Ajith Ukwatte for their tremendous support to make my effort successful. I also thank most sincerely my project supervisor Dr. M. A. R. V. Fernando for his advice and the valuable time spent to make this project a success.

I must thank the officers at the Municipal Councils and Pradeshiya Saba who helped me in data collection.

I like to thank all my colleagues for the great support extended to me throughout the course. I wish them all good luck. Finally I also thank all my friends who helped me in many ways to complete this project report.

Ananda Wijesinghe
ananda678@yahoo.com
December 2008

CONTENTS

PRE-CHAPTERS

TITLE	i
DECLARATION	ii
ABSTRACT	iii
ACKNOWLEDGEMENT	iv
CONTENTS	v
LIST OF TABLES	vii
LIST OF FIGURES	vii
LIST OF APPENDICES	ix
LIST OF ACRONYMS	ix

1 INTRODUCTION	1
1.1 Background of the research project	1
1.2 Four wheel tractor with an open trailer	2
1.3 The scope of the projected	3
1.4 The considerations for the design	3
2 LITERATURE REVIEW	5
2.1 Background of the solid waste generation	5
2.2 Evolution of municipal solid waste collection vehicles	9
2.3 Modern vehicles and mechanisms used for garbage collection and transportation	13
2.4 MSW collecting vehicles used in Sri Lanka	30
3 METHODOLOGY	39
3.1 Design Tree	40
3.2 Analysis of each problem	41
3.3 Possible sub solutions	45
3.4 Candidate solutions	49
3.5 The final selection of the design	50

4	DESIGN & STRENGTH CALCULATIONS OF THE BODY	51
4.1	The calculation of density of garbage	51
4.2	The analysis of loading capacity of existing tractor trailer	52
4.3	The pressures and forces acting on the compactor body	53
4.4	The design of components by manual calculations	67
5	FEM ANALYSIS BY COSMOSWorks SOFTWARE	73
5.1	FEM analysis for the compactor body	73
5.2	FEM analysis for the compacting door	83
5.3	FEM analysis for the compacting door hinge brackets	92
5.4	FEM analysis for the rear door	94
5.5	FEM analysis for the ejection plate	102
5.6	Final design	111
6	BILL OF QUANTITIES AND COST ESTIMATE FOR THE BODY AND HYDRAULIC SYSTEM	112
7	CONCLUSIONS	114
7.1	Discussion	114
7.2	Achievement of the design	115
7.3	Advantageous and Disadvantageous	116
7.4	Further Improvements	116
7.5	Summary	116
	REFERENCES	117

LIST OF TABLES

Table		Page
Table 2.1	Global perspective on refuse differences	6
Table 2.2	MSW generated within greater Colombo area	7
Table 2.3	Available vehicles at local government institution in Colombo district	35
Table 4.1	Weight measurements of a garbage dump truck	51
Table 4.2	Weight measurements of a compactor truck	52
Table 4.3	Load measurement of ejection plate	64
Table 4.4	Load measurement of side walls	65
Table 4.5	Design specifications	66

LIST OF FIGURES

Figure

Figure 1.1	Garbage collecting vehicles	2
Figure 2.1	MSW collection on road sides at Dehiwala municipal area	8
Figure 2.2	MSW Unloading at a dumping yard	8
Figure 2.3	The traditional form of collection	9
Figure 2.4	Non-motorized vehicles	10
Figure 2.5	Motorized vehicles	11
Figure 2.6	Compactor Truck	12
Figure 2.7	Typical front loader Garbage Truck in North America	13
Figure 2.8	Operating mechanism of front loader	14
Figure 2.9	Filling with cart tipper	15
Figure 2.10	Manual filling (Dehiwala area)	15
Figure 2.11	Typical view of the mechanism	17
Figure 2.12	Four steps in the mechanism of compaction	19
Figure 2.13	Side loading compactors (manual loading)	20
Figure 2.14	Automatic side loaders	21
Figure 2.15	Automatic side loaders	21
Figure 2.16	Operating mechanism	23
Figure 2.17	Grapple truck	24
Figure 2.18	Pneumatic collection vehicle	25

Figure 2.19	Rotary Compactors	26
Figure 2.20	Mechanism of Rotary Compactors	27
Figure 2.21	Operating sequence of the Container Carrier	28
Figure 2.22	Electric Garbage collecting vehicle	30
Figure 2.23	Human hand cart in Sri Lanka	31
Figure 2.24	Four wheel Tractor Trailers	32
Figure 2.25	Open Dump Truck	33
Figure 2.26	Container carrier	33
Figure 2.27	Rear loading hydraulic compactor truck	34
Figure 3.1	Compactor arrangement	50
Figure 4.1	Forces acting on compacting door	55
Figure 4.2	Ejection Mechanism of an existing compactor truck	57
Figure 4.3	Ejection plate – position 1	59
Figure 4.4	Ejection plate – position 2	60
Figure 4.5	Ejection plate – position 3	61
Figure 4.6	Spring Arrangement	63
Figure 4.7	Arrangement for measurement of pressure acting on ejection plate	63
Figure 4.8	Arrangement for measurement of pressure acting on side walls	65
Figure 4.9	Compactor body (SolidWorks model)	67
Figure 5.1	Compactor Body (SolidWorks model)	73
Figure 5.2	Compactor Body Assembly-Stress distribution - JPEG View	78
Figure 5.3	Compactor Body Assembly-Displacement - JPEG View	79
Figure 5.4	Compactor Body Assembly-Strain - PJEK View	80
Figure 5.5	Compactor Body Assembly-Design Check - JPEG View	81
Figure 5.6	Compacting Door -SolidWorks model	83
Figure 5.7	Compacting Door Assembly-Stress distribution - JPEG View	87
Figure 5.8	Compacting Door Assembly-Displacement - JPEG View	88
Figure 5.9	Compacting Door Assembly-Strain distribution - JPEG View	89
Figure 5.10	Compacting Door Assembly-Design Check - JPEG View	90
Figure 5.11	Stress analysis for compacting door hinge bracket - JPEG views	93
Figure 5.12	Rear Door (SolidWorks model)	94
Figure 5.13	Rear Door Assembly-Stress distribution - JPEG View	97
Figure 5.14	Rear Door Assembly-Displacement - JPEG View	98
Figure 5.15	Rear Door Assembly- Strain distribution - JPEG View	99

Figure 5.16	Rear Door Assembly-Design Check - JPEG View	100
Figure 5.17	Ejection Plate (SolidWorks model)	102
Figure 5.18	Ejection Plate Assembly-Stress distribution - JPEG View	106
Figure 5.19	Ejection Plate Assembly-Displacement - JPEG View	107
Figure 5.20	Ejection Plate Assembly-Strain distribution - JPEG View	108
Figure 5.21	Ejection Plate Assembly-Design Check - JPEG View	109
Figure 5.22	View of the complete body assembly	111

LIST OF APPENDICES

Appendix

Appendix A	: Drawing No 1	Compactor arrangement	119
Appendix B	: Drawing No 2	Forces acting on compacting door	120
Appendix C	: Ejection plate arrangement	– 3-D View	121
Appendix D	: Drawing No 3	Ejection plate – Position 1	122
Appendix E	: Drawing No 4	Ejection plate – Position 2	123
Appendix F	: Drawing No 5	Ejection plate – Position 3	124
Appendix G	: Drawing No 6	Ejection plate arrangement	125
Appendix H	: Drawing No 7	Compacting door	126
Appendix I	: Drawing No 8	Rear door	127
Appendix J	: Drawing No 9	Rear door arrangement	128
Appendix K	: Drawing No 10	Compactor body	129

LIST OF ACRONYMS

ASL	-	Automatic Side Loader
CMC	-	Colombo Municipal Council
DMMC	-	Dehiwala – Mount Lavinia municipal council
MC	-	Municipal Council
MSW	-	Municipal Solid Waste
PS	-	Pradeshiya Saba
SWM	-	Solid Waste Management
UC	-	Urban Council