ERGONOMIC CONSIDERATIONS FOR ASSEMBLY AND DISASSEMBLY OF CNG TANKS ON A VEHICLE

LO WOON CHEK.

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ERGONOMIC CONSIDERATIONS FOR ASSEMBLY AND DISASSEMBLY OF CNG TANKS ON A VEHICLE

By

LO WOON CHEK

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The use of natural gas as an automotive fuel is expanding worldwide, particularly so with the increasing price of petrol and diesel. Natural gas vehicle (NGV) is a relatively new and rapidly evolving technology in Malaysia. As of 2005, there were more than 12,000 NGVs and 38 refuelling stations available in the country. However, the use of natural gas as a vehicle fuel creates challenges in vehicle design. The installation of compressed natural gas (CNG) cylinders into the vehicle requires an analysis of the space availability, mounting system, design to assembly, disassembly and maintenance, fasteners operations, visibility and labelling issues, therefore creating a new impact on the vehicle design. In this study, a petrol fuelled sedan type passenger car has been chosen as a case study by its conversion to bi-fuelled and mono-fuelled NGV. A total of four designs have been introduced: locating the CNG
cylinders in the (i) luggage compartment and (ii) beneath the vehicle floor pan while retaining the original platform, also (iii) placing the cylinder under the backbone and (iv) rear platform by raising the floor. Ergonomics design guidelines and industrial NGV standards have played an important role in the design and design assessment. Many characteristics have been considered and studied to integrate the human into the system. These included equipment accessibility, workspace and operations, and physical accommodation. Virtual reality (VR), which enables the modelling of systems and components, was used for the simulation of assembly, disassembly, maintenance, reachability and visibility operations, and subsequently to evaluate and improve the designs. Concurrently, postural analyses were conducted using Rapid Upper Limb Assessment (RULA) technique. The virtual human contained within the VR software was used to perform the physical work, in an effort to reduce the risk of musculoskeletal disorder.
Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi sebahagian keperluan untuk ijazah Master Sains

PERTIMBANGAN ERGONOMI DALAM PEMASANGAN DAN PEMBUKAAN SILINDER CNG DALAM KERETA

Oleh

LO WOON CHEK

Mei 2006

Pengerusi: Profesor Madya Rosnah Mohd. Yusuff, PhD

Fakulti: Kejuruteraan

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I certify that an Examination Committee has met on 16 May 2006 to conduct the final examination of Lo Woon Chek on his Master of Science thesis entitled “Ergonomic Considerations for Assembly and Disassembly of CNG Tanks on a Vehicle” in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

Jamarei Bin Othman, PhD
Lecturer
Faculty of Engineering
Universiti Putra Malaysia
(Chairman)

Wong Shaw Voon, PhD
Associate Professor
Faculty of Engineering
Universiti Putra Malaysia
/Internal Examiner

Napsiah Ismail, PhD
Associate Professor
Faculty of Engineering
Universiti Putra Malaysia
/Internal Examiner

Zahari Taha, PhD
Professor
Faculty of Engineering
Universiti Malaya
/External Examiner

HASANAH MOHD. GHAZALI, PhD
Professor/Deputy Dean
School of Graduate Studies
Universiti Putra Malaysia

Date: 28 AUG 2006
This thesis submitted to the Senate of Universiti Putra Malaysia and has been accepted as partial fulfilment of the requirement for the degree of Master of Science. The members of the Supervisory Committee are as follows:

**Rosnah Mohd. Yusuff, PhD**  
Associate Professor  
Faculty of Engineering  
Universiti Putra Malaysia  
(Chairman)

**Ir. Barkawi Bin Sahari, PhD**  
Professor  
Faculty of Engineering  
Universiti Putra Malaysia  
(Member)

**Megat Mohamad Hamdan Megat Ahmad, PhD**  
Associate Professor  
Faculty of Engineering  
Universiti Putra Malaysia  
(Member)

---

**AINI IDERIS, PhD**  
Professor/Dean  
School of Graduate Studies  
Universiti Putra Malaysia  

Date: 14 SEP 2006
DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.

LO WOON CHEK
Date: 20 SEP 2006
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABSTRACT</td>
<td>ii</td>
</tr>
<tr>
<td>ABSTRAK</td>
<td>iv</td>
</tr>
<tr>
<td>ACKNOWLEDGEMENTS</td>
<td>vi</td>
</tr>
<tr>
<td>APPROVAL</td>
<td>vii</td>
</tr>
<tr>
<td>DECLARATION</td>
<td>ix</td>
</tr>
<tr>
<td>LIST OF TABLES</td>
<td>xiii</td>
</tr>
<tr>
<td>LIST OF FIGURES</td>
<td>xv</td>
</tr>
<tr>
<td>LIST OF ABBREVIATIONS</td>
<td>xix</td>
</tr>
</tbody>
</table>

# CHAPTER

1. **INTRODUCTION**
   - 1.1 Problem Statement
   - 1.2 Objectives
   - 1.3 Scope of the Study
   - 1.4 Significance of the Study
   - 1.5 Thesis Outline

2. **LITERATURE REVIEW**
   - 2.1 Natural Gas Vehicles
     - 2.1.1 Natural Gas
     - 2.1.2 Advantages and Disadvantages of CNG
     - 2.1.3 CNG Cylinders
     - 2.1.4 Considerations for CNG Cylinder Selection
     - 2.1.5 Labelling and Marking of CNG Cylinders
     - 2.1.6 Types of NGVs
     - 2.1.7 The Trend of NGV
   - 2.2 Ergonomics
     - 2.2.1 Ergonomics in Automotive Industry
     - 2.2.2 RULA Analysis
     - 2.2.3 Anthropometry
     - 2.2.4 Virtual Human
4.5 Conversion with Modification to the Vehicle Platform
   4.5.1 Front Platform 127
   4.5.2 Rear Platform 142
4.6 Visibility of Label and Marking on CNG Cylinders 161
4.7 Fuel Capacity 163
4.8 Discussion 166

5 CONCLUSION 167
5.1 Recommendations for Further Study 172

REFERENCES 174
APPENDICES 182
BIODATA OF THE AUTHOR 223
## LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1</td>
<td>RULA grand score and action level</td>
</tr>
<tr>
<td>2.2</td>
<td>Evaluation of assembly design</td>
</tr>
<tr>
<td>2.3</td>
<td>Maintainability evaluation factors</td>
</tr>
<tr>
<td>4.1</td>
<td>Vehicle characteristics for the NGV design</td>
</tr>
<tr>
<td>4.2</td>
<td>Specification of the selected Faber tank</td>
</tr>
<tr>
<td>4.3</td>
<td>RULA analysis on the virtual human</td>
</tr>
<tr>
<td>4.4</td>
<td>RULA analysis on the virtual human reaching for the extended valve</td>
</tr>
<tr>
<td>4.5</td>
<td>Spaces available underneath the vehicle platform after removal of the gasoline fuel tank</td>
</tr>
<tr>
<td>4.6</td>
<td>Maximum length and diameter for the cylinders underneath the vehicle</td>
</tr>
<tr>
<td>4.7</td>
<td>Specifications of the Faber tanks underneath the vehicle</td>
</tr>
<tr>
<td>4.8</td>
<td>RULA analysis on the virtual human ($5^{th}$ and $95^{th}$ percentile)</td>
</tr>
<tr>
<td>4.9</td>
<td>Specification of the special made cylinder at the new backbone</td>
</tr>
<tr>
<td>4.10</td>
<td>Specifications of the cylinders underneath the modified rear platform</td>
</tr>
<tr>
<td>4.11</td>
<td>RULA analysis on the virtual human assembling and disassembling the fasteners</td>
</tr>
<tr>
<td>4.12</td>
<td>RULA analysis on the virtual human assembling and disassembly the fasteners using the wrench extension</td>
</tr>
</tbody>
</table>
LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1</td>
<td>Basic construction of the four types of CNG fuel cylinders for NGV (Stephens et al., 2002)</td>
<td>16</td>
</tr>
<tr>
<td>2.2</td>
<td>The RULA scoring sheet</td>
<td>43</td>
</tr>
<tr>
<td>3.1</td>
<td>Process flow chart in this study</td>
<td>76</td>
</tr>
<tr>
<td>3.2</td>
<td>Conceptual flow of designing the fuel storage system (Stephens et al., 2002)</td>
<td>82</td>
</tr>
<tr>
<td>3.3</td>
<td>Basic chassis frame of the vehicle</td>
<td>83</td>
</tr>
<tr>
<td>3.4</td>
<td>The flow of CATIA V5 operation</td>
<td>90</td>
</tr>
<tr>
<td>4.1</td>
<td>Creating the Malaysian manikin in CATIA V5 software</td>
<td>95</td>
</tr>
<tr>
<td>4.2</td>
<td>Spaces available in the luggage compartment</td>
<td>98</td>
</tr>
<tr>
<td>4.3</td>
<td>Calculation of diameter of the cylinder</td>
<td>99</td>
</tr>
<tr>
<td>4.4</td>
<td>CNG system in the luggage compartment</td>
<td>101</td>
</tr>
<tr>
<td>4.5</td>
<td>Clearance inspection of the bolt on “V” shape support bar during assembly and disassembly</td>
<td>102</td>
</tr>
<tr>
<td>4.6</td>
<td>Clearance inspection of the bolt on mounting bracket during assembly and disassembly</td>
<td>102</td>
</tr>
<tr>
<td>4.7</td>
<td>Clearance inspection with 95th percentile Japanese male forearm</td>
<td>103</td>
</tr>
<tr>
<td>4.8</td>
<td>Simulation for reachability for the manual shut-off valve using 5th percentile Japanese female</td>
<td>104</td>
</tr>
<tr>
<td>4.9</td>
<td>Simulation for reachability after extended the valve</td>
<td>106</td>
</tr>
</tbody>
</table>
4.10 (a) The mannequin is preparing to reach for the spare wheel

4.10 (b) The arms of the mannequin turned into orange during initial lifting

4.10 (c) The arms changed back to yellow after the wheel if lifted

4.11 Spaces available underneath the vehicle platform, location A and B

4.12 Bottom isometric view of the rear platform after removed the original gasoline fuel tank

4.13 CNG cylinders mounted underneath the vehicle for location A and B

4.14 Bottom isometric view of the cylinders mounted underneath the vehicle

4.15 Bottom view of the cylinders mounted underneath the vehicle

4.16 Snug fit mounting of the cylinder

4.17 45 degrees slope of the fastener

4.18 Simulation of virtual human during assembly and disassembly

4.19 Visual span of the virtual human

4.20 Free-body diagram of segment one

4.21 Free-body diagram of segment two

4.22 The backbone at the front platform

4.23 The original and modified backbone

4.24 (a) Original backbone with 5th percentile female (isometric view)
New backbone with 5th percentile female (isometric view) 130

Original and new backbone (front view) 131

New backbone with CNG cylinder and mounting 132

Components of CNG mounting system 134

Disassembly simulation of the bolt using socket wrench 135

Disassembly of CNG cylinder mounted under the backbone 137

In-line type impact wrench 138

Pistol type impact wrench 139

Mounting bracket with a hinged unit 140

Disassembling operation of hinge-mounted cylinder 141

Comparison between original and modified rear platform 143

Modified rear seat placed on the new rear platform 144

Arrangement of the cylinder underneath the rear platform 146

Continuous flexible straps used for mounting 147

Tool access for the fasteners 148

Simulation of maintenance using virtual human 149

Vision span of the virtual human 150

Assembling and disassembling the fasteners using wrench extension 151

Free-body diagram of segment one (without wrench extension) 153

xvii
<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.42</td>
<td>Free-body diagram of segment one (with wrench extension)</td>
<td>155</td>
</tr>
<tr>
<td>4.43</td>
<td>Free-body diagram of segment two (without wrench extension)</td>
<td>157</td>
</tr>
<tr>
<td>4.44</td>
<td>Free-body diagram of segment two (with wrench extension)</td>
<td>159</td>
</tr>
<tr>
<td>Abbreviation</td>
<td>Description</td>
<td></td>
</tr>
<tr>
<td>--------------</td>
<td>-------------</td>
<td></td>
</tr>
<tr>
<td>3D</td>
<td>Three Dimensional</td>
<td></td>
</tr>
<tr>
<td>ANSI</td>
<td>American National Standards Institute</td>
<td></td>
</tr>
<tr>
<td>CAD</td>
<td>Computer Aided Design</td>
<td></td>
</tr>
<tr>
<td>CNG</td>
<td>Compressed Natural Gas</td>
<td></td>
</tr>
<tr>
<td>CNG-DI</td>
<td>Compressed Natural Gas Direct Injection</td>
<td></td>
</tr>
<tr>
<td>CTD</td>
<td>Cumulative Trauma Disorder</td>
<td></td>
</tr>
<tr>
<td>DFA</td>
<td>Design for Assembly</td>
<td></td>
</tr>
<tr>
<td>GLE</td>
<td>Gasoline Litre Equivalent</td>
<td></td>
</tr>
<tr>
<td>ISO</td>
<td>International Organization for Standardization</td>
<td></td>
</tr>
<tr>
<td>MSD</td>
<td>Musculoskeletal Disorder</td>
<td></td>
</tr>
<tr>
<td>NASA</td>
<td>National Aeronautics and Space Administration</td>
<td></td>
</tr>
<tr>
<td>NFPA</td>
<td>National Fire Protection Association</td>
<td></td>
</tr>
<tr>
<td>NGV</td>
<td>Natural Gas Vehicle</td>
<td></td>
</tr>
<tr>
<td>NIOSH</td>
<td>National Institute of Occupational Safety and Health</td>
<td></td>
</tr>
<tr>
<td>OEM</td>
<td>Original Equipment Manufacturer</td>
<td></td>
</tr>
<tr>
<td>OWAS</td>
<td>Ovako Working Posture Analyzing System</td>
<td></td>
</tr>
<tr>
<td>PNGV</td>
<td>PETRONAS NGV Sdn. Bhd.</td>
<td></td>
</tr>
</tbody>
</table>
PROTON  Perusahaan Otomobil Nasional Sendirian Berhad
REBA    Rapid Entire Body Assessment
RULA    Rapid Upper Limb Assessment
VR      Virtual Reality
CHAPTER 1

INTRODUCTION

Natural gas vehicle (NGV) technology has a long but sporadic history.

Environmental and energy supply concerns have received increasing attention in the past several decades, natural gas has been promoted as an alternative to petrol and diesel vehicles. The technology, marketing and political activities to support NGV commercialisation have grown substantially, particularly in the period of 1980 - 2000 (IANGV, 1998). Balancing the strengths and weaknesses of the fuel and vehicle technology, the fledgling NGV industry has an opportunity to change from an alternative fuel to a true fuel alternative.

NGV is a relatively new and rapidly evolving technology in Malaysia. As of 2005, there are more than 12,000 NGVs and 38 refuelling stations available in the country, compared to 975 converted NGVs and 8 refuelling stations in February 2000 (IANGV, 2004). These natural gas vehicles are mainly located in Klang Valley and Johor Bahru. Of this, retrofitted bi-fuel vehicles dominate the natural gas vehicle population in Malaysia with majority of the users being city taxis, while others
remain as airport tractors and forklifts. There is a drive to increase the share of natural gas in transportation energy. For this, there are two principal reasons, namely (a) reduction of emissions and (b) diversification of energy sources (Kojima, 2001).

Natural gas, as a cleaner burning fuel, significantly reduced exhaust emissions of other pollutants over all existing petroleum fuels and offers up to 100% reduction in particulate matter. The increase use of NGV can contribute to a reduction in urban air pollution and an improvement in air quality. Besides that, Malaysia has a large indigenous natural gas reserves but limited diversity. At \(2.336 \times 10^9\) m\(^3\) (82.5 trillion cubic feet), these reserves are two times the amount of oil. Before the introduction of NGV, natural gas is focused on heating, furnaces, cooking and electricity generation only. Because of these, the government is looking to diversity it supply alternatives for energy generation by attempt its use through NGV.

The development of NGV industry in Malaysia is led by PETRONAS NGV Sdn. Bhd, a wholly owned subsidiary of PETRONAS. In order to promote the use of natural gas in the transportation sector, PETRONAS launched the Natural Gas Vehicles program in 1991. During May 1992, 450 NGVs were introduced in Malaysia. Various incentives are provided to encourage the motoring public to use
NGV, while ongoing efforts are being undertaken to expand the NGV refuelling facilities in the country as well as to enhance public awareness on NGV and its benefits. PETRONAS arranges cheap loans for the conversion of vehicles at about RM 2,300.00, and organizes training program for mechanics. The government, through exemptions from import and excise duties, subsidizes the program. The retail price of fuel for natural gas vehicles has been set at half the price of premium petrol. PETRONAS also introduced the *Enviro 2000* NGV taxi in 1996 to further promote the use of NGV. The government is currently targeting buses as the next public transport to convert to NGV.

1.1 Problem Statement

On-board compressed natural gas (CNG) fuel storage presents unique challenges for the commercialization of natural gas vehicles. Vehicle range, storage system, durability, weight and compatibility of component material are all key issues (Haaland and Kunz, 2000). Natural gas has a low volumetric energy density compared to petrol. On average, it takes 0.921 cubic meters (m³) of natural gas to equal the same energy content as one litre (l) of gasoline (Boykiw, 1999; Kojima, 2001).
As of Malaysia, due to the small size of CNG cylinder mounted in the luggage compartment of the converted NGV and lack of refuelling stations, it has resulted in long queues at the refuelling stations. The low CNG cylinder capacity also contributes to low travel distance and hence require constant refuelling. In order to store sufficient natural gas on board, increase the travel range and reduce the refuelling rate, a higher CNG cylinder capacity that can be mounted on the vehicle should be considered. The cheaper price of natural gas compared to the ever increasing price of petrol, also drive the use of higher cylinder capacity. As the more fuel a vehicle can carry, the better the economic payback will be.

Currently, the selections of cylinders to be mounted during conversion for various types of vehicles are based on the range of CNG cylinder sizes available in the market. The cylinders were mostly fitted in the luggage compartment irrespective to the space available in the various car models. These can be clearly seen on the converted saloon type vehicles available in Malaysia. For example, even though the luggage space accessible in Proton Waja vehicle is more compared to the Proton Iswara vehicle, the size of the CNG cylinders mounted in the luggage compartment are the same, as only one size of cylinder is available for the saloon type vehicle from the conversion company.