MAINTENANCE MANAGEMENT PERFORMANCE
OF MALAYSIAN PALM OIL MILLS

By

NAZIM BALUCH

Thesis Submitted to
Othman Yeop Abdullah Graduate School of Business
Universiti Utara Malaysia
In Fulfillment of the Requirement for the Degree of Doctor of Philosophy
CERTIFICATION OF THESIS

“I hereby verify that this thesis is my own work except for those reviews for which I have discussed the sources”

09 August 2012

Nazim Baluch
(Metric # 92963)
PERMISSION TO USE

In presenting this thesis in fulfillment of the requirements for a Post Graduate degree from the Universiti Utara Malaysia (UUM), I agree that the Library of this university may make it freely available for inspection. I further agree that permission for copying of this thesis in any manner, in whole or in part, for scholarly purpose may be granted by my supervisor(s) or in their absence, by the Dean of Othman Yeop Abdullah Graduate School of Business where I did my thesis. It is understood that any copying or publication or use of this thesis or parts of it for financial gain shall not be allowed without my written permission. It is also understood that due recognition given to me and to the UUM in any scholarly use which may be made of any material in my thesis.

Request for permission to copy or make other use of materials in this thesis in whole or in part should be addressed to:

Dean of Othman Yeop Abdullah Graduate School of Business
Universiti Utara Malaysia
06010 UUM Sintok
Kedah Darul Aman
ABSTRACT

Performance of an organization should be appraised simultaneously, both in terms of its efficiency in resource utilization process and effectiveness in realizing the pre-determined goals. Measuring performance provides the required information to the management for effective decision making and is used by industries to assess progress against set goals and objectives in a quantifiable way. Deficient maintenance management can severely affect competitiveness of an organization by reducing throughput, increasing inventory, and leading to poor performance. Applying Overall Equipment Effectiveness, this research study, has evaluated maintenance management performance in Malaysian palm oil mills, highlighted how it helps to identify the factors causing poor performance and demonstrates how to improve and perpetuate company’s productivity, profits, and sustainability by adopting world class maintenance strategies such as Total Productive Maintenance. This research study supplicated data by mail survey questionnaire sent to all Malaysia palm oil mills, validated data through triangulation, and analyzed using descriptive statistics. The research exalts practitioner’s perspective and has determined that Scientific Management Theory axioms and Total Productive Maintenance principles are not being applied to optimize productivity in palm oil mills. The research also identified theory and practice gaps pertinent to maintenance management in palm oil mills and provided shop-level solutions to bridge those gaps. Research findings established how efficient and effective maintenance management offers, besides substantial cost savings, a wide scope of improvements for the palm oil industry. In order to ensure competitiveness and sustainability in the 21st century, it is obligatory for Malaysian palm oil mills to adopt best management practices in processing, manufacturing and maintenance.

Key Words: Maintenance management, Total Productive Maintenance, Measuring performance, Overall Equipment Effectiveness, Scientific Management Theory
**ABSTRAK**


**Kata Kunci:** Pengurusan Penyelenggaraan, TPM, OEE, SMT
ACKNOWLEDGEMENTS

First and foremost, I am highly grateful to God Almighty for blessing me with the strength, honor, and encouragement to complete this PhD.

I would like to express my gratitude and sincere thanks to my advisors: Prof. Ir. Dr. Che Sobry Abdullah and Prof. Madya Dr. Shahimi Mohtar for allowing me great flexibility during my studies and for their continuous guidance and support to my research. I will always be proud as a graduate of the Universiti Utara Malaysia.

I dedicate this thesis to my parents (deceased) who have been an inspiration role model for me throughout my life, and to the two persons I love most, my wife Fadia Baluch and my son Asim Baluch. I want to thank my lovely wife, Fadia for providing her encouragement, support and understanding throughout the years, as I worked endless hours on my doctorate, so I could fulfill my lifelong dream.
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>TITLE PAGE</td>
<td>i</td>
</tr>
<tr>
<td>CERTIFICATION OF THESIS</td>
<td>ii</td>
</tr>
<tr>
<td>PERMISSION TO USE</td>
<td>iv</td>
</tr>
<tr>
<td>ABSTRACT</td>
<td>v</td>
</tr>
<tr>
<td>ABSTRAK</td>
<td>vi</td>
</tr>
<tr>
<td>ACKNOWLEDGEMENTS</td>
<td>vii</td>
</tr>
<tr>
<td>LIST OF FIGURES</td>
<td>xv</td>
</tr>
<tr>
<td>LIST OF ABBREVIATIONS</td>
<td>xvi</td>
</tr>
<tr>
<td>LIST OF APPENDICES</td>
<td>xix</td>
</tr>
<tr>
<td>REFERENCES</td>
<td>251</td>
</tr>
<tr>
<td><strong>CHAPTER ONE: INTRODUCTION</strong></td>
<td>1</td>
</tr>
<tr>
<td>1.1 Introduction to Study</td>
<td>1</td>
</tr>
<tr>
<td>1.2 Background</td>
<td>1</td>
</tr>
<tr>
<td>1.2.1 Strategic Importance of Maintenance</td>
<td>1</td>
</tr>
<tr>
<td>1.2.2 Maintenance Performance Measurement</td>
<td>2</td>
</tr>
<tr>
<td>1.2.3 Performance Measurement - an effective management tool</td>
<td>4</td>
</tr>
<tr>
<td>1.2.4 Driving Factors behind MPM</td>
<td>4</td>
</tr>
<tr>
<td>1.2.5 OEE – TPM’s key performance indicator</td>
<td>6</td>
</tr>
<tr>
<td>1.2.6 Malaysian Palm Oil Industry – an overview</td>
<td>8</td>
</tr>
<tr>
<td>1.2.7 Industrial – biofuel use of palm oil</td>
<td>10</td>
</tr>
<tr>
<td>1.2.8 Sustainability and the Round Table on Sustainable Palm Oil</td>
<td>10</td>
</tr>
<tr>
<td>1.2.9 EUREPGAP and EU-RED Protocol</td>
<td>11</td>
</tr>
</tbody>
</table>
1.2.10 Concern over GMO food
1.2.11 Loss of Market Share

1.3 Problem Statement

1.3.1 Particular research has not been done in the field of maintenance performance evaluation in the palm oil mills
1.3.2 SME’s poor contribution to Malaysian GDP
1.3.3 Maintenance a low priority in Malaysian SMIs
1.3.4 Low productivity in palm oil mills hampering competiveness
1.3.5 Sustainable increase in productivity
1.3.6 Elevating Maintenance Function – The Financial Business
1.3.7 Malaysian Development Plan 2020

1.4 Research Questions

1.5 Research Objectives

1.6 Scope of this Research Study

1.6.1 Malaysian Palm Oil Mills
1.6.2 Upstream Producers
1.6.3 Downstream Producers

1.7 Significance of the Study

1.7.1 Palm Oil Mills and CDM Projects
1.7.2 Improve Foreign Exchange Earnings
1.7.3 Improve Sustainability – triple bottom line
1.7.4 Re-distribution of Wealth among Rural Population
1.7.5 Reduce Environmental Footprint – Green House Gases 31
1.7.6 Contribution to Knowledge 33
1.8 Thesis Organization 35

CHAPTER TWO: LITERATURE REVIEW 37

2.1 Introduction 37
2.2 Scope of Maintenance Management 38
2.3 The Maintenance Function 41
2.4 History of Maintenance Management 42
2.5 Maintenance Strategies 46
  2.5.1 Reactive or Breakdown Maintenance (BDM) 46
  2.5.2 Preventive Maintenance (PM) 47
  2.5.3 Condition-Based Maintenance (CBM) 47
  2.5.4 Reliability-Centered Maintenance (RCM) 48
  2.5.5 Total Productive Maintenance (TPM) 49
2.6 The Evolution of Performance Measurement 55
2.7 The Performance Measurement Revolution 57
  2.7.1 Financial Measures 59
  2.7.2 Reasons for Redesigning Business Performance Measures 61
2.8 Who Needs to Monitor Maintenance Performance and Why? 69
  2.8.1 Why Measure Maintenance Performance? 72
2.9 Description of the Maintenance Management Information System 74
  2.9.1 Strategic Planning 74
  2.9.2 Tactical Control 74
2.9.3 Operational Control 75

2.10 Maintenance Management Performance Evaluation 75

2.10.1 Mean Time between Failures (MTBF) 76

2.10.2 Mean Time to Repair (MTTR) 76

2.10.3 Percent Reactive Maintenance 76

2.10.4 OEE and Maintenance Performance Evaluation 77

2.11 Malaysian PO Industry – Scope, Importance and Challenges 81

2.11.1 Malaysian Palm Oil Industry and Palm Oil Mills 81

2.11.2 CPO Biodiesel Prospects 83

2.11.3 GAP and EU-RED 86

2.11.4 CPO Production Process & Developments in Milling Technology 87

2.11.5 Sustainability and the Round Table on Sustainable Palm Oil 93

2.11.6 Waste and Pollution from Palm Oil Production and Management 96

2.11.7 Clean Development Mechanism (CDM) Projects 101

2.11.8 Capitalizing on Palm Oil Sector Synergies 102

2.12 Underpinning Theory and Theoretical Framework 103

2.12.1 Scientific Management Theory (SMT) 105

2.12.2 Theoretical Framework 119

2.13 Chapter Summary 120

CHAPTER THREE: METHODOLOGY 122

3.1 Introduction 122

3.2 Maintenance Optimisation Models 123

3.3 Constraints in Applying Optimisation Models 124
3.4 Model and Framework applied in this study 131
   3.4.1 Spread of TPM 131
   3.4.2 Why TPM is so popular? 133
   3.4.3 TPM and OEE 135
   3.4.4 Data Collecting Issues and Challenges 137
   3.4.5 OEE Calculation, explained 140
   3.4.6 OEE 143
   3.4.7 MMPM Model Explained 144
3.5 Variables in this Research Study 145
   3.5.1 Independent Variable 145
   3.5.2 Moderator Variable 151
   3.5.3 Dependent Variable 151
3.6 Research Methodology 152
   3.6.1 Indexes of Population and Sample Design 153
   3.6.2 Measuring Instrument - Design, Testing and Validation 154
   3.6.3 Measuring Instrument – Survey Questionnaire 155
   3.6.4 Primary Data Collection and Validation 158
3.7 Chapter Summary 159

CHAPTER FOUR: RESULTS AND DISCUSSION 161
4.1 Introduction 161
4.2 Data Collection and Enumeration 162
   4.2.1 Data Validity and Reliability 164
   4.2.2 Data adaptations: presumptions conceived from the survey 165
4.2.3 Central Tendency

4.3 OEE – the Dependent Variable (DV)

4.3.1 Data Collecting Issues and Challenges – Theory Practice Gap

4.3.2 OEE: Cautions for using and Issues to be considered

4.4 Palm Oil Milling Sector ‘Inefficiency Cost’ Quantified

4.4.1 OEE

4.4.2 Yield

4.4.3 OER

4.5 Maintenance Inputs (IV): Sub-IVs and their Correlation with OEE

4.5.1 Labor in Theory and Practice: an analytical discourse

4.5.2 Spare-parts, Material, and Tools – (Sub-IV)

4.5.3 Maintenance Contracted Out

4.6 Moderator – Maintenance Strategy: TPM

4.6.1 TPM

4.6.2 Four Rules of Toyota Production System

4.7 POME Generated and POME Treated

4.8 Practical Implications

4.9 Chapter Summary

CHAPTER FIVE: CONCLUSION AND RECOMMENDATION

5.1 Introduction

5.2 OEE

5.3 Labor; Spare-parts, Material, & Tools; and Outsourced Maint.

5.3.1 Labor: Malaysian Skilled Labor Market
5.3.2 Spare parts Inventory Management 225

5.3.3 Outsourcing Maintenance: Power Generating Equipment in POM 226

5.4 Contribution to Knowledge 227

5.4.1 Identified Theory Practice Knowledge Gap pertinent to Maintenance Management Performance in Malaysian Palm Oil Mills 227

5.4.2 Modified ‘Input-Output Model for the Enterprise System’ 231

5.4.3 e-maintenance network concept for ‘Power Generating Equipment in Malaysian Palm Oil Mills’ 231

5.5 Research Findings 236

5.6 Research Accomplishments 239

5.7 Generalization 241

5.8 Recommendations for the Malaysian Palm Oil Milling Sector 244

5.9 Research Limitations 245

5.10 Future Research Recommendations 246

5.11 Chapter Summary 249
### LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure No.</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td>Global Palm Oil Production</td>
<td>9</td>
</tr>
<tr>
<td>1.2</td>
<td>Crude Palm Oil (CPO) yield potential in tons/ha/y</td>
<td>17</td>
</tr>
<tr>
<td>1.3</td>
<td>Per Capita GNI in US $ of selected countries</td>
<td>20</td>
</tr>
<tr>
<td>1.4</td>
<td>Crude Palm Oil Processing at MPOB mill</td>
<td>23</td>
</tr>
<tr>
<td>1.5</td>
<td>Oil Palm – the most productive crop</td>
<td>27</td>
</tr>
<tr>
<td>1.6</td>
<td>Carbon Dioxide footprint of palm oil</td>
<td>32</td>
</tr>
<tr>
<td>2.7</td>
<td>Eight Pillar Model of TPM (JIPM)</td>
<td>53</td>
</tr>
<tr>
<td>2.8</td>
<td>Tsang Input Output Model</td>
<td>119</td>
</tr>
<tr>
<td>2.9</td>
<td>Theoretical Framework</td>
<td>120</td>
</tr>
<tr>
<td>3.10</td>
<td>MMPM (Maintenance Management Performance Model)</td>
<td>145</td>
</tr>
<tr>
<td>3.11</td>
<td>Variables depicted in the framework</td>
<td>152</td>
</tr>
<tr>
<td>3.12</td>
<td>Graphic depiction of methodology</td>
<td>154</td>
</tr>
<tr>
<td>4.13</td>
<td>Central Tendencies</td>
<td>166</td>
</tr>
<tr>
<td>4.14</td>
<td>OEE: mean and standard deviation</td>
<td>171</td>
</tr>
<tr>
<td>4.15</td>
<td>Palm Oil Milling Sector ‘Inefficiency Cost’ Quantified</td>
<td>175</td>
</tr>
<tr>
<td>4.16</td>
<td>Maintenance Inputs and OEE Correlations</td>
<td>176</td>
</tr>
<tr>
<td>4.17</td>
<td>OEE Inputs and OEE Correlations</td>
<td>176</td>
</tr>
<tr>
<td>5.18</td>
<td>Diagram showing RPGDC Concept for Palm Oil Mills</td>
<td>234</td>
</tr>
<tr>
<td>5.19</td>
<td>Individual Mill Daily Production Log &amp; OEE Template</td>
<td>239</td>
</tr>
<tr>
<td>5.20</td>
<td>Maintenance Daily Service Log Template</td>
<td>240</td>
</tr>
</tbody>
</table>
LIST OF ABBREVIATIONS

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Full Form</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABI</td>
<td>American Business Institute</td>
</tr>
<tr>
<td>ABAC</td>
<td>Asia Business Advisory Council</td>
</tr>
<tr>
<td>ADB</td>
<td>Asian Development Bank</td>
</tr>
<tr>
<td>AGVs</td>
<td>Automated Guided Vehicles</td>
</tr>
<tr>
<td>AIA</td>
<td>American Institute of Accountants</td>
</tr>
<tr>
<td>AICPA</td>
<td>American Institute of Certified Public Accountants</td>
</tr>
<tr>
<td>APEC</td>
<td>Asia Pacific Economic Cooperation</td>
</tr>
<tr>
<td>APOC</td>
<td>American Palm Oil Council</td>
</tr>
<tr>
<td>BDM</td>
<td>Break Down Maintenance</td>
</tr>
<tr>
<td>BOD</td>
<td>Biochemical Oxygen Demand</td>
</tr>
<tr>
<td>CBM</td>
<td>Condition Based Maintenance</td>
</tr>
<tr>
<td>CDM</td>
<td>Clean Development Mechanism</td>
</tr>
<tr>
<td>CER</td>
<td>Certified Emission reductions</td>
</tr>
<tr>
<td>CI</td>
<td>Continuous Improvement</td>
</tr>
<tr>
<td>CIMA</td>
<td>Chartered Institute of Management Accountants</td>
</tr>
<tr>
<td>CM</td>
<td>Corrective Maintenance</td>
</tr>
<tr>
<td>CMMS</td>
<td>Computerized Maintenance Management System</td>
</tr>
<tr>
<td>CO₂</td>
<td>Carbon Dioxide</td>
</tr>
<tr>
<td>CPKO</td>
<td>Crude Palm Kernel Oil</td>
</tr>
<tr>
<td>CPO</td>
<td>Crude Palm Oil</td>
</tr>
<tr>
<td>CSR</td>
<td>Corporate Social Responsibility</td>
</tr>
<tr>
<td>DCS</td>
<td>Distributed Control Systems</td>
</tr>
<tr>
<td>DV</td>
<td>Dependent Variable</td>
</tr>
<tr>
<td>EFB</td>
<td>Empty Fruit Bunch</td>
</tr>
<tr>
<td>EPD</td>
<td>Environment Protection Department</td>
</tr>
<tr>
<td>ERV</td>
<td>Equipment Replacement Value</td>
</tr>
<tr>
<td>ETP</td>
<td>Economic Transformation Program</td>
</tr>
<tr>
<td>EU</td>
<td>European Union</td>
</tr>
<tr>
<td>EU-RED</td>
<td>European Union Renewable Energy Directive</td>
</tr>
<tr>
<td>FAO</td>
<td>Food and Agriculture Organization</td>
</tr>
<tr>
<td>FBM</td>
<td>Failure Based Maintenance</td>
</tr>
<tr>
<td>FDI</td>
<td>Foreign Direct Investment</td>
</tr>
<tr>
<td>FELCRA</td>
<td>Federal Land Consolidation &amp; Rehabilitation Authority</td>
</tr>
<tr>
<td>FELDA</td>
<td>Federal Land Development Authority</td>
</tr>
<tr>
<td>FFB</td>
<td>Fresh Fruit Bunch</td>
</tr>
<tr>
<td>FMEA</td>
<td>Failure Mode Effect Analysis</td>
</tr>
<tr>
<td>FMS</td>
<td>Flexible Manufacturing Systems</td>
</tr>
<tr>
<td>FRBD</td>
<td>Federal Reserve Bank Dallas</td>
</tr>
<tr>
<td>GAP</td>
<td>Good Agricultural Practices</td>
</tr>
<tr>
<td>GE</td>
<td>General Electric</td>
</tr>
<tr>
<td>GHG</td>
<td>Green House Gas</td>
</tr>
<tr>
<td>GMO</td>
<td>Genetically Modified Organism</td>
</tr>
<tr>
<td>GRI</td>
<td>Global Reporting Initiative</td>
</tr>
<tr>
<td>HACCP</td>
<td>Hazard Analysis Critical Control Points</td>
</tr>
<tr>
<td>Acronym</td>
<td>Full Form</td>
</tr>
<tr>
<td>---------</td>
<td>-----------</td>
</tr>
<tr>
<td>HSE</td>
<td>Health Safety &amp; Environment</td>
</tr>
<tr>
<td>ICAS</td>
<td>Institute of Chartered Accountants of Scotland</td>
</tr>
<tr>
<td>ICM</td>
<td>Integrated Crop Management</td>
</tr>
<tr>
<td>ICT</td>
<td>Information &amp; Communication Technology</td>
</tr>
<tr>
<td>IEC</td>
<td>International Electro-technical Commission</td>
</tr>
<tr>
<td>ILO</td>
<td>International Labour Organization</td>
</tr>
<tr>
<td>IPM</td>
<td>Institute of Personnel Management</td>
</tr>
<tr>
<td>ISO</td>
<td>International Organization for Standardization</td>
</tr>
<tr>
<td>IT</td>
<td>Information Technology</td>
</tr>
<tr>
<td>IV</td>
<td>Independent Variable</td>
</tr>
<tr>
<td>JIPM</td>
<td>Japan Institute of Plant Management</td>
</tr>
<tr>
<td>JIT</td>
<td>Just in Time</td>
</tr>
<tr>
<td>KPI</td>
<td>Key Performance Indicator</td>
</tr>
<tr>
<td>LCC</td>
<td>Life Cycle Costing</td>
</tr>
<tr>
<td>LED</td>
<td>Light Emitting Diodes</td>
</tr>
<tr>
<td>LM</td>
<td>Lean Manufacturing</td>
</tr>
<tr>
<td>LTP</td>
<td>Long Term Program</td>
</tr>
<tr>
<td>MACC</td>
<td>Malaysian Anti Corruption Commission</td>
</tr>
<tr>
<td>MCC</td>
<td>Milling Certificate of Competency</td>
</tr>
<tr>
<td>MDG</td>
<td>Millennium Development Goal</td>
</tr>
<tr>
<td>MESA</td>
<td>Maintenance Engineering Society of Australia</td>
</tr>
<tr>
<td>MFF</td>
<td>Mesocarp Fruit Fiber</td>
</tr>
<tr>
<td>MIAC</td>
<td>Malaysian International Aerospace Centre</td>
</tr>
<tr>
<td>MIDA</td>
<td>Malaysian Industrial Development Authority</td>
</tr>
<tr>
<td>MIER</td>
<td>Malaysian Institute of Economic Research</td>
</tr>
<tr>
<td>MMIS</td>
<td>Maintenance Management Information Systems</td>
</tr>
<tr>
<td>MMPM</td>
<td>Maintenance Management Performance Model</td>
</tr>
<tr>
<td>MPM</td>
<td>Maintenance Performance Measurement</td>
</tr>
<tr>
<td>MPOA</td>
<td>Malaysian Palm Oil Association</td>
</tr>
<tr>
<td>MPOB</td>
<td>Malaysian Palm Oil Board</td>
</tr>
<tr>
<td>MPOC</td>
<td>Malaysian Palm Oil Council</td>
</tr>
<tr>
<td>MQA</td>
<td>Malaysian Qualification Agency</td>
</tr>
<tr>
<td>MRO</td>
<td>Maintenance Repair &amp; Overhaul</td>
</tr>
<tr>
<td>MTBF</td>
<td>Mean Time between Failures</td>
</tr>
<tr>
<td>MTTR</td>
<td>Mean Time to Repair</td>
</tr>
<tr>
<td>MV</td>
<td>Moderating Variable</td>
</tr>
<tr>
<td>NEM</td>
<td>New Economic Model</td>
</tr>
<tr>
<td>NGO</td>
<td>Non Governmental Organization</td>
</tr>
<tr>
<td>NKEA</td>
<td>National Key Economic Areas</td>
</tr>
<tr>
<td>O&amp;M</td>
<td>Operations &amp; Maintenance</td>
</tr>
<tr>
<td>OA</td>
<td>Operational Availability</td>
</tr>
<tr>
<td>OEE</td>
<td>Overall Equipment Effectiveness</td>
</tr>
<tr>
<td>OEM</td>
<td>Original Equipment Manufacturers</td>
</tr>
<tr>
<td>OER</td>
<td>Oil Extraction Rate</td>
</tr>
<tr>
<td>OLE</td>
<td>Overall Labour Efficiency</td>
</tr>
<tr>
<td>OPIEJ</td>
<td>Oil Palm Industries Economic Journal</td>
</tr>
<tr>
<td>Abbreviation</td>
<td>Description</td>
</tr>
<tr>
<td>--------------</td>
<td>-------------</td>
</tr>
<tr>
<td>O&amp;R</td>
<td>Operations &amp; Reliability</td>
</tr>
<tr>
<td>OR</td>
<td>Operations Research</td>
</tr>
<tr>
<td>PAM</td>
<td>Physical Asset Management</td>
</tr>
<tr>
<td>PKS</td>
<td>Palm Kernel Shells</td>
</tr>
<tr>
<td>PM</td>
<td>Preventive Maintenance</td>
</tr>
<tr>
<td>POME</td>
<td>Palm Oil Mill Effluent</td>
</tr>
<tr>
<td>POMTEC</td>
<td>Palm Oil Mill Technology Center</td>
</tr>
<tr>
<td>PORIM</td>
<td>Palm Oil Research Institute of Malaysia</td>
</tr>
<tr>
<td>PORLA</td>
<td>Palm Oil Registration and Licensing Authority</td>
</tr>
<tr>
<td>QOS</td>
<td>Quality Operating Systems</td>
</tr>
<tr>
<td>R&amp;D</td>
<td>Research and Development</td>
</tr>
<tr>
<td>R&amp;M</td>
<td>Reliability and Maintainability</td>
</tr>
<tr>
<td>RAV</td>
<td>Replacement Asset Value</td>
</tr>
<tr>
<td>RCM</td>
<td>Reliability Centered Maintenance</td>
</tr>
<tr>
<td>RF</td>
<td>Radio Frequency</td>
</tr>
<tr>
<td>RISDA</td>
<td>Rubber Industry Small Holders Development Authority</td>
</tr>
<tr>
<td>ROI</td>
<td>Return on Investment</td>
</tr>
<tr>
<td>RONA</td>
<td>Return on Net Assets</td>
</tr>
<tr>
<td>RPGDC</td>
<td>Remote Power Generating Diagnostics Centre</td>
</tr>
<tr>
<td>RSPO</td>
<td>Roundtable Sustainable Palm Oil</td>
</tr>
<tr>
<td>SALCRA</td>
<td>Sarawak Land Rehabilitation &amp; Consolidation Authority</td>
</tr>
<tr>
<td>SCM</td>
<td>Supply Chain Management</td>
</tr>
<tr>
<td>SKU</td>
<td>Stock Keeping Unit</td>
</tr>
<tr>
<td>SLDB</td>
<td>Sabah Land Development Board</td>
</tr>
<tr>
<td>SME</td>
<td>Small &amp; Medium Enterprises</td>
</tr>
<tr>
<td>SMI</td>
<td>Small &amp; Medium Industries</td>
</tr>
<tr>
<td>SMT</td>
<td>Scientific Management Theory</td>
</tr>
<tr>
<td>SS</td>
<td>Six Sigma</td>
</tr>
<tr>
<td>TBL</td>
<td>Triple Bottom Line - People, Planet, Profit</td>
</tr>
<tr>
<td>TEEP</td>
<td>Total Equipment Effectiveness Performance</td>
</tr>
<tr>
<td>TOC</td>
<td>Theory of Constraints</td>
</tr>
<tr>
<td>TPM</td>
<td>Total Productive Maintenance</td>
</tr>
<tr>
<td>TQM</td>
<td>Total Quality Management</td>
</tr>
<tr>
<td>TSS</td>
<td>Total Suspended Solids</td>
</tr>
<tr>
<td>UBM</td>
<td>Use Based Maintenance</td>
</tr>
<tr>
<td>UK</td>
<td>United Kingdom</td>
</tr>
<tr>
<td>UN</td>
<td>United Nations</td>
</tr>
<tr>
<td>UNCED</td>
<td>United Nations Conference on Environment &amp; Development</td>
</tr>
<tr>
<td>UNEP</td>
<td>United Nations Environment Program</td>
</tr>
<tr>
<td>USA</td>
<td>United States of America</td>
</tr>
<tr>
<td>USDA</td>
<td>United States Development Agency</td>
</tr>
<tr>
<td>USDOC</td>
<td>United States Department of Commerce</td>
</tr>
<tr>
<td>USITC</td>
<td>United States International Trade Commission</td>
</tr>
<tr>
<td>VBM</td>
<td>Vibration Based Maintenance</td>
</tr>
<tr>
<td>WCM</td>
<td>World Class Manufacturing</td>
</tr>
<tr>
<td>WO</td>
<td>Work Order</td>
</tr>
</tbody>
</table>
### LIST OF APPENDICES

<table>
<thead>
<tr>
<th>Appendix</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>SURVEY QUESTIONNAIRE for Malaysian palm oil mills</td>
<td>273</td>
</tr>
<tr>
<td>B</td>
<td>SURVEY QUESTIONNAIRE – Head Offices palm Oil Mills</td>
<td>274</td>
</tr>
<tr>
<td>C</td>
<td>Cover Letter Palm Oil Mills</td>
<td>275</td>
</tr>
<tr>
<td>D</td>
<td>Cover Letter Head Offices</td>
<td>276</td>
</tr>
<tr>
<td>E</td>
<td>Pilot Study Observation and Notes</td>
<td>277</td>
</tr>
<tr>
<td>F</td>
<td>List of General Palm Oil Mill Equipment</td>
<td>278</td>
</tr>
<tr>
<td>G</td>
<td>Mill Survey Data</td>
<td>279</td>
</tr>
<tr>
<td>H</td>
<td>OER and OEE Calculation</td>
<td>280</td>
</tr>
</tbody>
</table>
CHAPTER ONE

1.0 INTRODUCTION

1.1 Introduction to the Study

Management is obliged to measure performance of their organizations for effective decision making to ensure sustainable profits. This research study espousing practitioner’s perspective will employ Overall Equipment Effectiveness (OEE), key performance indicator (KPI) of Total Productive Maintenance (TPM), to evaluate maintenance management performance in Malaysian palm oil mills and accent poor performance stimulating determinants. The study will discuss moderating effects of maintenance strategy, TPM, to improve palm oil mills’ productivity, profits, and sustainability. Adopting world class maintenance strategy, TPM, would enable to establish palm oil sectors’ competitiveness in the 21st century.

1.2 Background

1.2.1 Strategic Importance of Maintenance

Intense competitive pressure is triggering many companies to look for every possible source of competitive advantage. To achieve this, the ingenuity of each company lies in understanding the potential of each function – say, for example, manufacturing or maintenance. Once understood, it requires a proper strategy to exploit such potential. Strategy at any level, say at a business and functional level will provide the company with a sense of direction, integrity and purpose (Pintelon, Pinjala, & Vereecke, 2006). Tsang (2002) reported that maintenance plays a vital role in any organization using machinery and should be incorporated into an organizations’ business model.
The contents of the thesis is for internal user only
REFERENCES


APOC (2010). American Palm Oil Council, Palm Oil development and performance in Malaysia, MPOB & APOC Presentation to USITC Washington DC, Feb. 3, 2010


264


Round Table on Sustainable Palm Oil FACT SHEET (2012), pp. 3-4, retrieved from: http://www.rspo.org/sites/default/files/RSPOFACTSHEETFINALRT91.pdf


