

# OVERALL EQUIPMENT EFFECTIVENESS SYSTEM



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# OVERALL EQUIPMENT EFFECTIVENESS SYSTEM



**By**

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## ABSTRACT

Modern manufacturing equipment has become highly automated and sophisticated. High levels of output can now be achieved, hence the need to monitor the production process. The greatest hindrance to achieve higher output are the six big losses to production. The six big losses are start-up rejects, production rejects, small stops, setup and adjustment, equipment failure and slow cycles. In order to counteract these losses it is necessary to monitor machinery performance through the calculation of overall equipment effectiveness (OEE). In this regard Mega Pak Zimbabwe employed a manual system to track and monitor OEE. The process was tedious and consumed a lot bond paper. The main object of this project is the creation of a computerised system to efficiently monitor, trend and evaluate OEE at Mega Pak Zimbabwe. It also seeks to compare target OEE against actual OEE and notify the plant manager when OEE has decreased below target. Questionnaires, interviews and observations were used to gather information on how OEE was being monitored. It was noted that employees complained that the process of calculating OEE was time consuming and prone of errors resulting in misleading results. Development tools used include MySQL, Apache, PHP and Sublime text editor. Based on gathered information a feasibility study was conducted to assess the economic, technical and social viability of the project. In-house development was selected as the most appropriate development strategy given the prevailing economic situation. Multiple tests including acceptance test, integration test and performance test were conducted on the system to ensure that it meets user requirements and is free of bugs. To prevent confusion regarding the use of the new system a pilot changeover strategy was employed. This gave employees enough time to adjust to the demands of the new system. Employees were trained on how to use the different functions they had access to such as adding new production details and customising reports. Maintenance of the system will be an ongoing process in order to carry out planned maintenance and incorporate new user requirements. For future development it was recommended that the system be integrated with electronic dashboards or televisions in the production area to give shifts a visual appreciation of their work rate. An effective OEE system will among other thing help Mega Pak Zimbabwe to maintain their position as the leading plastic manufacturing company in Zimbabwe.

## DECLARATION

I, **Quinton Abel Chabvuta**, hereby declare that I am the sole author of this dissertation. I authorize the **Midlands State University** to lend this dissertation to other institutions or individuals for the purpose of scholarly research.

Signature.....

Date.....

## APPROVAL

This dissertation, entitled “**Overall Equipment Effectiveness**” by **Quinton A Chabvuta** meets the regulations governing the award of the degree of **BSc Honours Information Systems** of the **Midlands State University**, and is approved for its contribution to knowledge and literary presentation.

Supervisor’s Signature: .....

Date: .....

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## **DEDICATION**

I dedicate this project to my brothers Kundai Matingo and Marshal Chabvuta.

## TABLE OF CONTENTS

ABSTRACT .....	i
DECLARATION .....	ii
APPROVAL .....	iii
ACKNOWLEDGEMENTS .....	iv
DEDICATION.....	v
TABLE OF CONTENTS .....	vi
LIST OF ACRONYMS.....	xi
LIST OF FIGURES .....	xii
LIST OF TABLES .....	xiv
LIST OF APPENDICES .....	xv
CHAPTER ONE: INTRODUCTION .....	1
1.1 INTRODUCTION .....	1
1.2 BACKGROUND OF STUDY .....	1
1.2.1 BACKGROUND OF THE ORGANISATION.....	2
1.2.2 ORGANIZATIONAL STRUCTURE .....	2
1.2.3 VISION .....	3
1.2.4 MISSION STATEMENT.....	4
1.3 PROBLEM DEFINATION.....	4
1.4 AIM.....	5
1.5 OBJECTIVES .....	5
1.6 INSTRUMENTS AND METHODOLOGIES .....	5
1.6.1 INSTRUMENTS .....	5
1.6.2 METHODOLOGIES .....	6
1.7 JUSTIFICATION AND RATIONALE.....	7
1.8 CONCLUSION .....	7



CHAPTER TWO: PLANNING PHASE .....	8
2.1 INTRODUCTION .....	8
2.2 BUSINESS VALUE .....	8
2.3 FEASIBILITY STUDY .....	10
2.3.1 TECHNICAL FEASIBILITY .....	10
2.3.1.1 SOFTWARE REQUIREMENTS .....	10
2.3.1.2 HARDWARE REQUIREMENTS .....	11
2.3.1.3 TECHNICAL EXPERTISE .....	12
2.3.2 ECONOMIC FEASIBILITY .....	12
2.3.2.1 DEVELOPMENT COSTS .....	13
2.3.2.2 OPERATIONAL COSTS .....	13
2.3.2.3 BENEFITS .....	14
2.3.2.5 APPRAISAL TECHNIQUES .....	15
2.3.3 SOCIAL FEASIBILITY .....	17
2.4 RISK ANALYSIS .....	18
2.4.1 ECONOMIC RISK .....	18
2.4.2 TECHNICAL RISK .....	18
2.4.3 RISK OF RESISTANCE TO CHANGE .....	18
2.5 STAKEHOLDER ANALYSIS .....	18
2.6 WORK PLAN .....	19
2.6.1 WORK PLAN .....	19
2.7 CONCLUSION .....	20
CHAPTER THREE: ANALYSIS PHASE .....	21
3.1 INTRODUCTION .....	21
3.2 INFORMATION GATHERING METHODOLOGIES .....	21
3.2.1 INTERVIEWS .....	21
3.2.1.1 RESULTS .....	22

3.2.2 OBSERVATION .....	22
3.2.2.1 RESULTS.....	23
3.2.3 QUESTIONNAIRES .....	23
3.3 ANALYSIS OF THE EXISTING SYSTEM.....	24
3.4 PROCESS ANALYSIS .....	25
3.5 DATA ANALYSIS .....	27
3.5.1 CONTEXT DIAGRAMS OF THE CURRENT SYSTEM .....	27
3.5.2 DATA FLOW DIAGRAM OF THE CURRENT SYSTEM .....	28
3.6 WEAKNESS OF THE CURRENT SYSTEM.....	30
3.7 EVALUATION OF ALTERNATIVES .....	31
3.7.1 OUTSOURCING.....	31
3.7.2 IMPROVEMENT .....	31
3.7.3 IN-HOUSE DEVELOPMENT.....	32
3.7.4 ALTERNATIVE SELECTION.....	33
3.8 REQUIREMENTS ANALYSIS .....	33
3.8.1 FUNCTIONAL REQUIREMENTS .....	33
3.8.1.1 USE CASE DIAGRAM.....	34
3.8.2 NON-FUNCTIONAL REQUIREMENTS .....	34
3.9 CONCLUSION .....	35
CHAPTER FOUR: DESIGN PHASE .....	36
4.1 INTRODUCTION .....	36
4.2 SYSTEM DESIGN .....	36
4.2.1 CONTEXT DIAGRAM OF THE PROPOSED SYSTEM.....	36
4.2.2 DATAFLOW DIAGRAM OF THE PROPOSED SYSTEM .....	37
4.3 ARCHITECTURAL DESIGN .....	39
4.4 PHYSICAL DESIGN .....	39
4.4.1 SOFTWARE AND HARDWARE REQUIREMENTS .....	40

4.5 DATABASE DESIGN.....	41
4.5.2 TABLE DESIGN.....	43
4.5.3 ENHANCED ENTITY RELATIONSHIP DIAGRAM (EER).....	46
4.6 PROGRAM DESIGN .....	46
4.6.1 PACKAGE DIAGRAM.....	47
4.6.2 CLASS DIAGRAM.....	48
4.6.3 SEQUENCE DIAGRAM.....	50
4.7 INTERFACE DESIGN.....	51
4.7.1.1 MAIN MENU.....	51
4.7.1.2 SUB MENUS .....	52
4.7.2 INPUT DESIGN .....	53
4.7.3 OUTPUT DESIGN .....	57
4.8 PSEUDO CODE.....	62
4.8.1 PSEUDO CODE FOR LOGIN FORM.....	62
4.8.2 PSEUDO CODE FOR ADDING NEW PRODUCTION DETAILS .....	63
4.8.3 PSEUDO CODE FOR UPDATING PRODUCTION DETAILS .....	63
4.8.4 PSEUDO CODE FOR ADDING DOWNTIME DETAILS .....	64
4.8.5 PSEUDO CODE FOR CALCULATING DAILY OEE.....	64
4.9 SECURITY DESIGN .....	65
4.9.1 PHYSICAL SECURITY.....	66
4.9.2 NETWORK SECURITY .....	66
4.9.3 OPERATIONAL SECURITY.....	66
4.10 CONCLUSION .....	67
CHAPTER FIVE: IMPLEMENTATION PHASE.....	68
5.1 INTRODUCTION .....	68
5.2 CODING .....	68
5.3 TESTING.....	68

5.3.1 UNIT TESTING .....	70
5.3.2 SUBSYSTEM TESTING.....	72
5.3.3 SYSTEM TESTING .....	72
5.3.4 ACCEPTANCE TESTING .....	73
5.3.5 VERIFICATION AND VALIDATION .....	73
5.3.5.1 VERIFICATION .....	73
5.3.5.2 VALIDATION .....	74
5.3.5.3 TEST CASES .....	75
5.3.5.4 SECURITY TESTING.....	78
5.3.6 USABILITY TESTING .....	79
5.3.7 PERFORMANCE TESTING.....	79
5.3.7.1 STRESS TEST.....	80
5.3.8 SYSTEM OBJECTIVES VERSUS SYSTEM SOLUTION .....	80
5.4 INSTALLATION .....	86
5.4.1 USER TRAINING.....	86
5.4.2 DATA MIGRATION.....	87
5.4.3 SYSTEM CHANGEOVER.....	88
5.4.3.1 DIRECT CHANGEOVER .....	88
5.4.3.2 PILOT CHANGEOVER.....	88
5.4.3.3 PHASED CHANGEOVER.....	89
5.4.3.5 RECOMMENDED CHANGEOVER STRATEGY .....	89
5.5 MAINTENANCE.....	90
5.6 RECOMMENDATIONS FOR FUTURE DEVELOPMENT .....	91
5.7 CONCLUSION .....	92
REFERENCE LIST .....	93
APPENDICES .....	98

## **LIST OF ACRONYMS**

ISO – International Organisation for Standardisation

FSSC – Food Safety System Certification

OPEX – Operational Excellence

SOP – Standard Operating Procedure

OEE – Overall Equipment Effectiveness

IS – Information System

LAN – Local Area Network

GUI – Graphical User Interface

CBA – Cost Benefit Analysis

ROI – Return on investment

NPV – Net Present Value

DFD - Data flow diagram

UML – Unified modelling language

RAM – Random access memory

DMZ – Demilitarized zone

CLI – Command line interface

IDS – Intrusion detection software

ER – Entity relationship diagram

EER – Enhanced entity relationship diagram

VLAN – Virtual local area network

## LIST OF FIGURES

Fig 1.1: Organogram.....	3
Fig 3.1: Activity diagram.....	26
Fig 3.2: Context diagram of the current system.....	28
Fig 3.3: Data flow diagram of the current system.....	29
Fig 3.4: Use case.....	34
Fig 4.1: Context diagram of the proposed system.....	37
Fig 4.2: Data flow diagram of the proposed system.....	38
Fig 4.3: Physical design.....	40
Fig 4.4: ANSI-SPARC model.....	42
Fig 4.5: EER diagram.....	46
Fig 4.6: Package diagram.....	47
Fig 4.7: Class diagram.....	49
Fig 4.8: Sequence diagram.....	50
Fig 4.9: Main menu.....	51
Fig 4.10: Production clerk menu.....	52
Fig 4.11: Plant manager menu.....	52
Fig 4.12: Login form.....	53
Fig 4.13: Operator dashboard.....	54
Fig 4.14: Quality controller dashboard.....	54
Fig 4.15: Manage machines.....	55
Fig 4.16: Change password.....	55
Fig 4.17: User management.....	56
Fig 4.18: Factory management.....	57
Fig 4.19: Daily OEE dashboard.....	58
Fig 4.20: Custom OEE dashboard.....	58
Fig 4.21: Machine OEE dashboard.....	59
Fig 4.22: Factory OEE dashboard.....	59
Fig 4.23: Daily OEE report.....	60
Fig 4.24: Custom OEE report.....	61
Fig 4.25: Machine OEE report.....	61
Fig 4.26: Factory OEE report.....	62
Fig 4.27: Security design.....	65

Fig 5.1: Black-box testing.....	69
Fig 5.2: Testing process.....	70
Fig 5.3: Login module unit testing.....	71
Fig 5.4: Downtime module testing.....	72
Fig 5.5: Machine addition validation.....	74
Fig 5.6: User add case.....	75
Fig 5.7: Shift details case.....	75
Fig 5.8: Update production case.....	76
Fig 5.9: Downtime case.....	76
Fig 5.10 OEE per day case.....	77
Fig 5.11: Login credentials validation.....	77
Fig 5.12: Login security testing.....	78
Fig 5.13: Incorrect designation case.....	95
Fig 5.14: Daily machine OEE.....	80
Fig 5.15: Weekly machine OEE.....	81
Fig 5.16: Monthly machine OEE.....	81
Fig 5.17: Custom Machine OEE.....	82
Fig 5.18: Improvement suggestion.....	83
Fig 5.19: Actual versus target OEE.....	84
Fig 5.20: Plant manager notification.....	84
Fig 5.21: Loss analysis.....	85
Fig 5.22: Depreciation versus OEE.....	86
Fig A1: Login form.....	98
Fig A2: Login form.....	99
Fig A3: Plant manager dashboard.....	100
Fig A4: Range OEE.....	100
Fig A5: Add products.....	101
Fig A6: Machine custom report.....	101
Fig A7: Production clerk dashboard.....	102
Fig A8: Add production.....	102
Fig A9: Update production.....	103

## LIST OF TABLES

Table 2.1: Software requirements.....	10
Table 2.2: Database server requirements.....	11
Table 2.3: Hardware requirements.....	11
Table 2.4: Computer specifications.....	11
Table 2.5: Development costs.....	13
Table 2.6: Operational costs.....	13
Table 2.7: Intangible benefits.....	14
Table 2.8: Tangible benefits.....	14
Table 2.9: Cost benefit analysis.....	15
Table 2.10: Payback period.....	17
Table 2.11: Work plan.....	19
Table 2.12: Gantt chart.....	19
Table 3.1: In-house development.....	32
Table 3.2: Development alternative.....	33
Table 4.1: Login.....	43
Table 4.2: Machine details.....	43
Table 4.3: Factory details.....	43
Table 4.4: Production details.....	44
Table 4.5: Quality details.....	44
Table 4.6: OEE details .....	45
Table 4.7: Employee details.....	45
Table 4.8: Product details.....	45
Table 4.9: Department details.....	45



**LIST OF APPENDICES**

APPENDIX A: USER MANUAL.....98  
APPENDIX B: INTERVIEW.....104  
APPENDIX C: QUESTIONNAIRE CHECKLIST.....106  
APPENDIX D: OBSERVATION SCORE SHEET.....108  
APPENDIX E: SNIPPET OF CODE.....109

# **CHAPTER ONE: INTRODUCTION**

## **1.1 INTRODUCTION**

Since the acquisition of Mega Pak Zimbabwe by Nampak South Africa many Standard Operating Procedures (SOPs) have changed. Nampak is an Operational Excellence (OPEX) oriented company. OPEX is a strategy where an organisation is focused on meeting customer expectation through improvement of organisational processes (Issar and Navon, 2016). The main pillars of OPEX are “Buy better, Make better and Sell better”. In this spirit high Overall Equipment Effectiveness (OEE) is among the prerequisite programs to achieve OPEX. The proposed system was aimed at developing a computerised system that will produce reports necessary for management review regarding OEE of the organisation on a weekly and monthly basis. The system will generate reports, produce trends and give possible suggest on the best possible solution to resolve low OEE. The background, vision, mission, and core values of Mega Pak Zimbabwe were all discussed in this chapter. This chapter outlines the challenges being faced by the organisation in raising their OEE. It also addresses the challenge of analysing data received from machine operators, regarding quality, downtime and output. Formulation of objectives will assist in providing suggestions about how the proposed system will go about resolving problems in the system currently in use. This chapter highlights the objectives of the proposed system to come up with a better solution. Instruments for system development and methodologies for data gathering are included towards the end of this chapter.

## **1.2 BACKGROUND OF STUDY**

The earliest known form of manufacturing was generally carried out by a single skilled artisan. Since the industrial revolution this has changed. Modern manufacturing is now carried out by multiple complex and semi-autonomous machinery. In this scenario it is important to monitor the effectiveness of the machines to ensure that preventable losses are not incurred. A good measure of machine effectiveness is OEE. OEE comprises of availability, performance and quality. At Mega Pak Zimbabwe there are multiple machines and factories, manually monitoring OEE would be time consuming. The development of the proposed system was motivated by inefficient manual process that was being used which produces incorrect results which resulted in misinformed decisions being made. This project seeks to develop a computerised system that assist Mega Pak Zimbabwe in OEE monitoring and management. As a manufacturing company Mega Pak has to ensure that it is using

efficient equipment. There is need to reduce the effect of the major losses of product in order to achieve the best results from the equipment being used. There is need to constantly monitor and evaluate OEE levels and take appropriate measures when needed. The OEE system will assist in evaluating the efficiency of all machines and factories and suggest corrective measures where appropriate. The manufacturing department at Mega Pak will be the department that will make us the OEE system.

### **1.2.1 BACKGROUND OF THE ORGANISATION**

Mega Pak Zimbabwe was is a joint venture between Delta Corporation of Zimbabwe and Nampak South Africa. Delta Corporation at inception had 51% and Nampak Group of South Africa had (49%). Currently Nampak South Africa is now the major shareholder of Mega Pak Zimbabwe. On the 22nd of August 2014 Hunyani shareholders approved the acquisition of Carnand Metal box (CMB) and Mega Pak through the issue of shares to the existing CMB and Mega Pak shareholders. This came after Nampak a major shareholder in Hunyani expressed interests in expanding its investments in the packaging industry through consolidation of its Zimbabwe operations.

Due to the dynamic manufacturing environment, Mega Pak has attained the ISO 14001 and FSSC 22000 certificates and is moving towards Willis Blue and Operational Excellence (OPEX) certificates for the best food safety management system. The company specialises in food packaging products ranging from water tanks, bread crates, PET bottles and various types of closures. It employs a number of technologies that include blow moulding, stretch blow moulding and injection moulding.

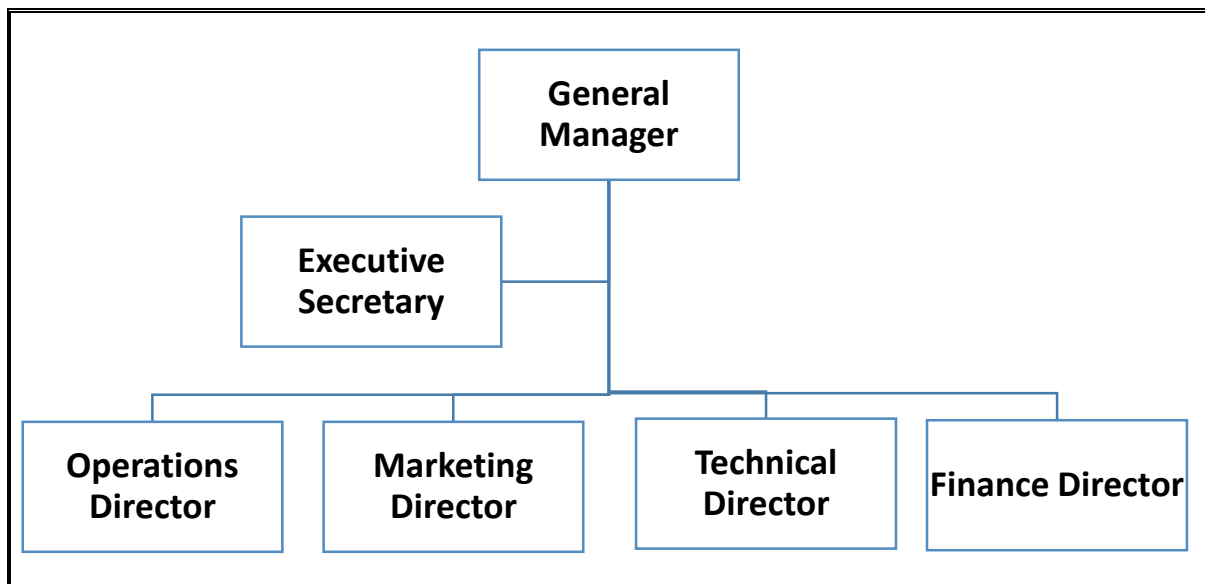
Mega Pak is located at number 211 Chihombe road in Ruwa. It has two other branches, with one located in Bulawayo and the other at the showground stands in Harare

### **1.2.2 ORGANIZATIONAL STRUCTURE**

Jones, George, Barret and Honing (2016), define an organizational structure is a formal system of task and job reporting relationship among the employees in an organisation. Jones et al, (2016) go on to mention that there are two basic types in organisational structures which are the behavioural and the traditional structures. A traditional structure has a high centralisation of power and is pyramid shaped. On the other hand a behavioural structure is decentralised. The Mega Pak management team comprises of the General Manager, 4

directors and 4 executive managers. They have a Technical Director, Operations Director, Finance Director and Sales and Marketing Director. Each director is followed by a long chain of subordinates. The board of directors is responsible for formulating strategic plans for the organisation. Each director heads a department which therefore implements the ideas proposed by the senior management. A traditional organisational structure is currently being used at Mega Pak as shown in Fig 1.1

### MEGA PAK ZIMBABWE (PVT) LTD ORGANOGRAM



**Fig 1.1: Organogram for Mega Pak Zimbabwe (Pvt) Ltd**

### 1.2.3 VISION

A vision is a statement expressing a company's most desired future state (Hill and Jones 2009). It explicitly points out what an organisation seeks to achieve. According to Mega Pak Zimbabwe, their vision is:

To strive to be the best in every market segment they decide to play in. Mega Pak Zimbabwe will offer total packaging solutions and transform into a highly efficient company across a wide variety of market segments.

#### **1.2.4 MISSION STATEMENT**

Hill and Jones(2009) define a mission statement as a simple description of a company is all about. It often includes the main strategy being focused pursued by the organisation. The mission statement at Mega Pak Zimbabwe reads:

To market and manufacture a wide variety of plastics packaging products. To grow shareholder return on sustainable basis is our overriding. To our stakeholders we seek to enhance the value we create for them.

#### **1.3 PROBLEM DEFINITION**

A problem definition according Locander and Cocanougher(2012), is a process of critically examining the present situation and identify weaknesses. The present system at Mega Pak involves machine operators bringing production sheets to the plant manager. The production clerks records this information in excel and give it to the plant manager who then presents it to senior management concerning OEE on a weekly basis. This process increases the workload on both the manager and production clerks and may result in the production of inconsistent results. Computerised systems have become a must in this era of computerisation and artificial intelligence. The raw data from the production sheets may be entered into the system and analysis and graphs are automatically generated by the system. The current system lacks the requisite capabilities to produce desired information and hence is very inefficient. Storing information in a database allows the administrator to back up the information and store it at a secure location and access the information later. Without daily analysis of OEE it is difficult to trace and pinpoint machine problems. Lack of daily updates results in information getting lost. Unnecessary duplication may occur as a result of storing information on papers because previous entries may be difficult to find. Due to multiple duplications, the current system lacked accuracy as data was enter multiple times.

## 1.4 AIM

An aim according to Mahammed (2014), is a broad statement of the overall purpose of a study and the desired outcomes. The main objective are to develop and design a computerised system to efficiently monitor, trending and identifying problems related to OEE at Mega Pak Zimbabwe. The system will suggest alternatives on how to improve and maintain OEE as well as notify the plant manager when the OEE is below acceptable levels.

## 1.5 OBJECTIVES

Objectives are the breakdowns of aims. They are stated and measurable targets about how to achieve the aim (Singh 2006).

- ❖ To measure individual machine effectiveness on a daily, weekly and monthly basis.
- ❖ To suggest to the plant manager possible alternatives for reducing the losses to production and improve OEE.
- ❖ To provide a comparison between actual OEE and Target OEE on a daily, weekly and monthly basis.
- ❖ To notify the plant manager through the dashboard when a machines OEE levels decrease below set targets.
- ❖ To measure and monitor losses to production and evaluate their impact on a machine OEE.
- ❖ To evaluate the effects of machine depreciation on OEE on a monthly basis.

## 1.6 INSTRUMENTS AND METHODOLOGIES

The following section looks at the instruments and methodologies used to computerise the system currently in use at Mega Pak Zimbabwe.

### 1.6.1 INSTRUMENTS

Instruments are the tools that are used creating and designing a new software application (DuBois, 2013). The following instruments are going to be used to create a computerised OEE system at Mega Pak Zimbabwe:

- ❖ **Bootstrap** – it is a front end development framework that is open source and free which is used in creating websites (Spurlock, 2013).
- ❖ **MySQL** –it is a comprehensive set of tools used in managing a database. MySQL is an open source relational database management system (RDBMS). It enables roust

data searching, sorting and retrieval. Concurrent access to the same data by multiple users is permissible (DuBois, 2013).

- ❖ **PHP**– PHP: Hypertext Preprocessor is a language designed for dynamic websites. It is a server side scripting language but is also used for general purpose programming (McLaughlin, 2012).
- ❖ **Apache** – It is a free, cross platform, open source and most widely used web server (Park, 2018). It is highly customizable for multiple environments.
- ❖ **Sublime text 3** –Sublime text is a super-fast cross platform code editor (Peleg, 2013).

The above set of instruments were selected in order to produce a robust, secure and responsive online based system that can be accessed from multiple locations.

## 1.6.2 METHODOLOGIES

Methodologies section takes a look at the different data gathering techniques used to capture information about how the current system operates.

### ❖ **Interviews**

Interviews are a data gathering technique that uses telephone conversation or formal meetings to gather information (Walliman, 2010). Interviews were conducted by the researcher at Mega Pak Zimbabwe where the interviewer asked both structured and unstructured questions. Structured question give the interviewee less room to digress from the question while unstructured questions give the interviewee much room to structure their answer in a more comfortable way. Interviews were conducted with the plant manager, production clerks and executive managers. The purpose of interviewing the above mentioned people was to determine how the current system functioned and the problems being faced. For the purpose of reducing ambiguity detailed information was gathered.

### ❖ **Observation**

According to Walliman (2010), an observation is a form of data gathering where data is gathered directly from the environment by closely watching the behaviour of individuals and processes within a system. At Mega Pak Zimbabwe the researcher conducted non-participative observations. Entities within the system were unaware that they were being observed. The researcher had enough time to appreciate how the

current system works. Observation aided the researcher in coming up with a clear picture of the problems being faced and enabled the researcher to anticipate unforeseen challenges.

#### ❖ **Questionnaire**

Walliman (2010), defines questionnaires as method of gathering data by sending the respondents multiple questions. Open ended questions in a questionnaire make room for lengthy answers while close ended questions require a straight forward answer. Structured and semi-structured questions were distributed to the plant manager, production clerks and executive managers. More questions were asked using questionnaires than with interviews in gathering information about how the current system works.

### **1.7 JUSTIFICATION AND RATIONALE**

The problem definition outlined multiple problems currently being faced regarding the use of the current system at Mega Pak Zimbabwe. Information systems (IS) have come to be regarded as a pivotal element in an organisation to support business integration and collaboration. The proposed system creates a computerised system not only to improve the reporting of OEE to management, but also provides a facility for trending and tracking of the OEE of each machine on a daily, weekly, monthly and yearly basis. The company will enjoy a high OEE due to system generated suggestions on how to tackle the different OEE levels. It will also reduce the workload on the plant manager and production clerk giving them ample time to focus on more important issues.

### **1.8 CONCLUSION**

Highlighted in this chapter was the organisational history, aims and business objectives. Problems being faced at the organisation as a result of using the current system were also mentioned as well as proposed alternative solutions to the problems. The proposed system seeks to deal with problems being faced. The justification and rationale mentions the need for a computerised system to resolve the inefficiencies of the current system. The following chapter takes a look at the feasibility of the project. It also outlines the business value of implementing the system at Mega Pak Zimbabwe.



## **CHAPTER TWO: PLANNING PHASE**

### **2.1 INTRODUCTION**

The previous chapter looked at the background of study and the background of the organisation highlighting the aims, vision and organisational structure. Also highlighted in the previous chapter are the instruments and methodologies to be used. The planning phase focuses on carrying out a feasibility study and defining a detailed solution. An in-depth consideration is carried out for all the required material to build a computerised system. Reasons for developing the proposed system are also outlined in this chapter. To check the feasibility of the project a feasibility study was conducted. The study checked whether the organisation had adequate to complete the project. Feasibility study will focus on four main areas: social feasibility, economic feasibility, operational feasibility and technical feasibility.

### **2.2 BUSINESS VALUE**

Osterwalder et al (2015), defined business values as the different forms of value that when combined result in overall financial wellbeing of an organisation.

Since the acquisition of Mega Pak Zimbabwe by Nam Pak, the thrust has been focused on improving the safety of around the workplace. As a result of this focus many systems have been put in place to ensure achievement of this goal. Such systems include Willies Blue and operational excellence (OPEX). OPEX has three main pillars which are: buy better, make better and sell better. Constantly recording and checking the organisations OEE is one of the prerequisite programs. The proposed system will be a computerised system with the capability to allow instant access to OEE records from different location.

The development of this system is in line with Nampak South Africa's vision for Mega Pak Zimbabwe. The system augments the position and vision being pursued at Mega Pak Zimbabwe. Monitoring OEE will result in effective and efficient usage of existing equipment. This will help the organisation produce more products without having to invest in increasing production capacity. This is achieved by reducing downtime and improving machine operator efficiency. OEE in this sense aims towards using the best possible production process, increasing profitability and promoting economic survival.

Morale among employees may be increased as a result of reduced workload. Previously production clerks had to work long hours and go home late as they tried to compute the OEE. This will no longer be the case as the system will now be able to automatically compute the OEE for different time periods.

Order completion dates can be estimated with greater degree of certainty. It is very important to correctly estimate order completion dates since most of Mega Pak's customers are also producers themselves such as Delta and Dairiboard, and need to satisfy their also. Trending OEE would allow for the implementation just in-time system for production. Trends show the times in which output is highest allowing the organisation to adequately respond to customer demands as they arise. By being able to trend OEE over large periods of time it will be possible to anticipate production capacity. A consistent trend would mean that customers can be provided with more accurate delivery dates.

The procurement department may be able to implement just-in-time ordering. OEE provides organisations with the awareness of real time activities. It gives management the true state of the production process taking place in the factory. Through its use manufacturing constraints and production deficiencies can be uncovered and resolved. Precise information will be provided by the proposed system to support management decision making. Raw material will be ordered when needed to prevent unnecessary wastages and decay.

The plant manager and senior management can also be able to make informed decisions. A computerised system makes it easier to visualise information on the efficiency of each machine. By taking a look at the important sources of productivity losses and filtering them into categories of availability, quality and performance it is easy to identify areas that are in need of improvement. For decision making purposes a high correlation between decreasing depreciation and low OEE then it might be the appropriate time to replace the machine.

- ❖ **Decision making value** – The system has a comprehensive database implying that data can be stored over large periods of time. Historical data allows for better analysis of trends per machine and per factory resulting in informed decisions being made regarding each machine or the factory as a whole.

- ❖ **Workers value** – Frustration and fatigue greatly reduce the efficiency of a worker. The proposed system will reduce the workload on the production clerk and improve morale and motivation.
- ❖ **Functional value** – Time taken to record and analyse OEE per machine and per factory will be reduced. The plant manager and management would have to wait less time to view daily OEE values.
- ❖ **Security value** – Information regarding the organisation’s OEE will be stored in a database and access will be restricted through the use of passwords. This will result in increased confidentiality and protection of the organisation’s information.

## 2.3 FEASIBILITY STUDY

Feasibility study is an activity carried out with the intent of determining whether it is financially, operationally, socially and technically feasible to carry out a particular system (Mali, 2004). The feasibility study looks at the extent to which it is possible to develop an OEE system for Mega Pak Zimbabwe. Mali (2004) goes further to outline the different areas to consider when carrying out a feasibility study. These areas are technical feasibility, operational feasibility, financial feasibility and social feasibility. By determining what the organisation requires to develop the system compared to what it currently has it is possible to determine the feasibility of a project. After the feasibility study a recommendation is given to Mega Pak on whether or not to continue with the current project.

### 2.3.1 TECHNICAL FEASIBILITY

Glass (2003) pointed out that technical feasibility considers the availability and capacity of the organisation to acquire the required infrastructure, tools and expertise to develop, install and maintain the system.

#### 2.3.1.1 SOFTWARE REQUIREMENTS

*Table 2.1: Software requirements*

Description	Quantity	Availability	Recommendations
Windows 8 Professional	1	Available	
MySQL database server	1	Available	
Xampp	1	Available	
Macromedia Dreamweaver 8	1	Available	

Listed in Table 2.1 are the software requirements to develop the proposed system. A database server would be necessary to store real time transactions and historic data.

**Table 2.2 Database server specifications**

<b>Description</b>	<b>Specifications</b>	<b>Availability</b>	<b>Solution</b>
Processor	Intel core i3 3.60 GHz	Not Available	To buy
RAM	4GB	Not Available	To buy
System type	64-bit operating system	Not Available	To buy
HDD	500GB	Not Available	To buy
Network card	10/100 mbps	Not Available	To buy
DVD / CD drive	52x read, 24x write	Not Available	To buy

For optimum performance the database host machine should meet specifications in Table 2.2

### **2.3.1.2 HARDWARE REQUIREMENTS**

**Table 2.3: Hardware requirements**

<b>Description</b>	<b>Quantity</b>	<b>Availability</b>	<b>Solution</b>
HP desktop computers	3	Available	
HP Probook 450	1	Not available	To buy
HP LaserJet 750 printer	1	Not available	To buy
Cisco 8 port switch	3	Available	
TP-Link wireless access point	1	Not available	To buy
Apc Interrupted power supply	1	Not available	To buy

Table 2.3 outlines the hardware required in order for the system to function. Computers available at the organisation are modern and meet the requirements in Table 2.4.

**Table 2.4: Computer requirements**

<b>Item</b>	<b>Suggested specifications</b>	<b>Availability</b>	<b>Solution</b>
Processor	Intel Dual core 2.5 GHz	Available	
RAM	2GB	Not available	To upgrade
HDD	500GB	Available	

Computers are required to conform to specifications outlined in Table 2.4 for optimum performance.

### **2.3.1.3 TECHNICAL EXPERTISE**

According to Glass (2003), technical expertise are the minimum skill level required of individuals who interact with a particular system.

**a) Developer** – In order to be able to take advantage of the different programming and scripting languages available the developer should have a high skills, expertise and experience level with at least one programming language. The developer should also be very creative in creating captivating and easy to navigate web pages. After all website development is more of an art than a science. The developer is well equipped with all the necessary knowledge, experience and skills in order to develop the required system.

**b) Users** – A general knowledge of using a computer is required. The user should be able to perform simple functions such as input, edit and delete data as well as be able to navigate the graphical user interface (GUI) of the windows operating system. Users have a basic understanding of a computer and how to use it thus need to undergo a general computer usage course in order to reinforce their knowledge on the usage of a computer in order to effectively perform data manipulation in the system.

**c) Management** – Reports will use different graphs including pie charts, bar graphs and line graphs to represent information. Management should be able to interpret results and trends presented in the form of graphs. Management are able to interpret graphs however also need to undergo a further tutorial to assist them on interpreting the graphs. This includes identifying patterns and correlations among other important relationships.

### **2.3.2 ECONOMIC FEASIBILITY**

Glass (2003) defines economic feasibility as an assessment to determine whether the economic benefits to be enjoyed are greater than the cost of implementing the project. The starting point is to identify and quantify all benefits and costs. Costs and benefits are then compared and if the benefits are greater than costs, the project is economically feasible. Costs

include development cost development and operational cost while benefits can be subcategorised into tangible and intangible benefits.

### 2.3.2.1 DEVELOPMENT COSTS

Development costs are costs associate with developing the system (Glass, 2003). They occur before the system is in use. These costs are incurred by database designers, programmers, system analysts among others. The virtual host at the organisation will be used as the database server.

*Table 2.5: Development costs*

Description	Quantity	Amount (\$)
HP Probook 450	1	1200
Apc uninterruptd power supply	1	1000
TP-Link wireless access point	4	200
HP LaserJet m750 printer	1	2500
<b>Total</b>		<b>4900</b>

### 2.3.2.2 OPERATIONAL COSTS

Glass, (2003) outlined that operational costs are costs that the organisations starts to incur as soon as the system is implemented. Replacement costs will continue to rise due to depreciation of various hardware components.

*Table 2.6: Operational costs*

Description	2018 (\$)	2019 (\$)	2020 (\$)	Total (\$)
System maintenance	300	300	200	800
Training costs	400	0	0	400
Replacement costs	50	150	400	600
Stationary	100	100	100	300
<b>Total</b>	<b>910</b>	<b>610</b>	<b>760</b>	<b>2280</b>

### 2.3.2.3 BENEFITS

Leach, (1999) defined benefits as the overall improvement in an organisation's health after they decide to implement a particular course of action. They are divided into intangible and tangible benefits.

#### b) Intangible benefits

Glass (2004) says that intangible are benefits that can neither be measured nor touched. Customer goodwill and loyalty are examples. The value of staff productivity is estimated from increase in output as a result of reduced errors

*Table 2.7: Intangible benefits*

Description	2018 (\$)	2019 (\$)	2020 (\$)	Total
Staff productivity	2200	1100	900	4200
<b>Total</b>	<b>2200</b>	<b>1100</b>	<b>900</b>	<b>4200</b>

#### a) Tangible benefits

Mali (2004) explains that tangible benefits can have a monetary value can be assigned to them and have a physical existence.

*Table 2.8: Tangible benefits*

Description	2018 (\$)	2019 (\$)	2020 (\$)	Total (\$)
Decreased labour costs	8100	0	0	8100
Decreased telephone bills	600	300	100	1000
Decreased stationary costs	2100	500	500	3100
<b>Total</b>	<b>10800</b>	<b>800</b>	<b>600</b>	<b>12200</b>

From Table 2.7 it is clear that labour costs will reduce in the first year is an assistant clerk will no longer be required.

### 2.3.2.4 COST BENEFIT ANALYSIS (CBA)

According to Quah and Toh (2011), CBA is the evaluation of costs against benefits of a particular business action. It summaries all benefits and costs to be incurred in the project. It

sees to clarify whether undertaking the project will result in an overall beneficial position for the organisation.

**Table 2.9: Cost benefits analysis**

	2018 (\$)	2018 (\$)	2020 (\$)	Total (\$)
<b>Benefits</b>				
Tangible benefits	10800	800	600	12200
Intangible benefits	2200	1100	900	4200
<b>Total benefits</b>	<b>13000</b>	<b>1900</b>	<b>1500</b>	<b>16400</b>
<b>Costs</b>				
Development costs	4900	0	0	4900
Operating costs	910	610	760	2280
<b>Total costs</b>	<b>5810</b>	<b>610</b>	<b>760</b>	<b>7180</b>
<b>Net Benefit (Cost)</b>	<b>7190</b>	<b>1290</b>	<b>740</b>	<b>9220</b>

From Table 2.9 it is clear that the project will greatly benefit the organisation, benefits outweigh costs by \$9220. This would result in an overall improved position for the organisation. It is prudent therefore for Mega Pak to undertake this project since it has an overall economic benefit.

### 2.3.2.5 APPRAISAL TECHNIQUES

a) **Return on Investment (ROI)** – Downes and Goodman (2003), affirm that ROI is a performance indicator used by businesses in order to evaluate how efficient an investment is.

Calculation:

$$\begin{aligned}
 \text{ROI} &= (\text{Net profit} / \text{total investment}) * 100 \\
 &= (16400 - 7180) / 7180 * 100 \\
 &= \underline{128 \%}
 \end{aligned}$$

If ROI is positive it means the organisation made a profit, a negative ROI means the organisation made a loss. By choosing to carry out this project the organisation will make a 28% profit.



**b) Net present value (NPV)** – is the value in the present of money in comparison to the value in the future if invested at a compound interest rate.

Calculation:

t – Number of time period

r – Rate of return

Assuming a discount rate of 8.2%

Present Value	$= \frac{\text{Value in year (t)}}{(1+r^t)}$	
Year 0	$= \frac{-7180}{1+0.82^0}$	= -7180
Year 1	$= \frac{13000}{1+0.82^1}$	= 7143
Year 2	$= \frac{1900}{1+0.82^2}$	= 574
Year 3	$= \frac{1500}{1+0.82^3}$	= 249

$$\begin{aligned}\text{NPV} &= \sum \text{Present values} \\ &= -7180 + 7143 + 574 + 249 \\ &= \underline{786}\end{aligned}$$

From the value of the NPV it is clear that the project is a good investment since value of money now is greater than its value in the future if invested at a compound interest. Mega Pak's overall financial position will be improved by investing in this project.

**c) Payback period** – This is the number of years and months required for a project to return its initial investment

**Table 2.10: Payback Period**

<b>Year number</b>	<b>Expected net cash inflow</b>	<b>Net invested cash</b>
0	0	(7180)
1	13000	5820
2	1900	7720
3	1500	9220

Calculation:

$$= (7180 / 13000) * 12$$

$$= 6.6 \text{ months}$$

$$= 6 \text{ months } 18 \text{ days}$$

A payback period of approximately 7 months is very much to be desired. Long payback periods for small amounts is not desirable since the money can be put to better use. The downside of using the payback period is that it does not measure profitability and cash flows after the payback period.

### **2.3.3 SOCIAL FEASIBILITY**

Simon (2007), articulates that social feasibility assess the impact to the society of any planned action. The impact may be on social groups within the organisation or on the organisational layout.

- ❖ The proposed system will not result in radical changes to the organisation's structure
- ❖ Due to a reduce workload, production clerks may get motivated to work harder
- ❖ Retrenchment of workers may negatively affect those who stay as result the proposed system will shift the production clerk assistant to other areas that are short staffed.
- ❖ Communication among the different levels of management may be improved through the use of the system
- ❖ Existing social groups within the organisation will remain unaffected

### **2.3.4 OPERATIONAL FEASIBILITY**

According to Simons (2007), operational feasibility assess the extent to which a system will be able to support the necessary tasks of a process. Operationally feasible systems satisfy the needs of a business.

- ❖ By being automated the system simplifies the workload of the employees
- ❖ User training will help equip users with the basic skills about to efficiently operate the system
- ❖ Use of graphs in reports greatly aids in analysis of given information
- ❖ Informative error messages will help users identify their error and quickly correct it

## **2.4 RISK ANALYSIS**

Risk analysis take an in-depth analysis of uncertainties in the business environment that to determine their effect on the probability of the organisation failing or succeeding (Simons, 2007). Included in risk analysis is economic risk, resistance to change and technical risk. It is a proactive method of dealing with risk before it occurs. Forecasting works together in trying to mitigate the negative impact of unforeseen events.

### **2.4.1 ECONOMIC RISK**

Due to the unstable economic situation within the country there is a risk that budgets may change without notice. Such changes may jeopardise the timely completion of the project. It might be necessary to put aside reserve funds aside just in case the economic situation deteriorates further.

### **2.4.2 TECHNICAL RISK**

Users with inadequate computer skills may find it difficult to efficiently operate and navigate in the new system. User training and manuals will be provided for the users to refer to just in case they face a challenge.

### **2.4.3 RISK OF RESISTANCE TO CHANGE**

Sabotage is common among employees if they feel that their jobs may be threatened by the introduction of a new system. The organisation may be able to address this by increasing employee salary.

## **2.5 STAKEHOLDER ANALYSIS**

This is the process of systematically arranging different interest groups to be affected by project on the basis of how they are going to be affected (Simons, 2007).

### 2.5.1 Production clerks

This is the most affected group. They will experience reduced workload and increased morale. The system will be semi-automated resulting in automatic creation of graphs. Trending OEE over longer period of time is much easier. Work that previously took days to complete will be completed in a matter of hours.

### 2.5.2 Plant manager

The plant manager as the overseer of all production will also enjoy a reduced workload as well as accurate analysis of results to present to management. Customised reports and a centralised database will together assist the plant manager to retrieve the exact information which is required from the database in a much less space of time.

### 2.5.3 Management

With the aid of visual representation of reports management will be able to quickly comprehend information presented to them, understand it and make quick and informed decisions.

## 2.6 WORK PLAN

A work plan is a document used by an organisation to organise and coordinate its various projects (Mehdi, 2008). It shows that time span to be consumed by each project and shows how the organisation plans to carry out the project till the end.

### 2.6.1 WORK PLAN

*Table 2.11: Work plan*

Step	Start date	Finish date	Duration
Proposal	17/01/18	28/01/18	2
Planning	31/01/18	11/02/18	2
Analysis	14/02/18	01/03/18	3
Design	04/03/18	27/04/18	8
Implementation	30/04/18	17/05/18	3
Maintenance	20/05/18	Ongoing	1+++
Documentation	17/01/18	Ongoing	19+++

Table 2.11 outlines the start date, finish date and duration of each activity within a project.

### 2.6.2 Gantt chart

Gantt charts are a series of horizontal lines which represent periods of time in which a certain task is expected to be completed (Mehdi, 2008). It shows all stages involved starting with proposal until the maintenance stage.

*Fig 2.1: Gantt chart*

	January			February				March				April				May				
	17	24	31	7	14	21	28	4	11	18	25	2	9	16	23	30	6	13	20	27
<b>Proposal</b>	■	■																		
<b>Planning</b>			■	■																
<b>Analysis</b>					■	■	■													
<b>Design</b>								■	■	■	■	■	■	■	■					
<b>Implementation</b>																■	■	■		
<b>Maintenance</b>																			■	■
<b>Documentation</b>	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■

Table 2.12 gives a visual illustration of the time taken to complete each stage. The whole project has a total duration of 18 weeks. Development will take a long period of time in order to give time for verifying code and ensuring that bugs are eliminated.

### 2.7 CONCLUSION

After undertaking a feasibility analysis it was clearly determined that the project was viable. Net benefits from the project were much higher than the costs. Mega Pak Zimbabwe will enjoy an immediate reduction in costs. From fig 2.1 the project will take an average of 20 weeks to be completed. Data analysis and the different information gathering techniques will be looked at in the following chapter.

## **CHAPTER THREE: ANALYSIS PHASE**

### **3.1 INTRODUCTION**

The focus of this chapter is on the different data gathering methodologies applied to data gathering. The main data gathering techniques used are interviews, observations and questionnaires. Later on data flow diagrams (DFD), will be used to provide a data analysis of the current and proposed system. From the weaknesses of the current system alternative development methods will be developed. The advantages and disadvantages of each development solution is analysed towards the end of the chapter.

### **3.2 INFORMATION GATHERING METHODOLOGIES**

It is a task concerned with collecting and arranging data to be used for research purposes (Sapsford and Jupp, 2006). Observations, interviews and questionnaires were used in the data gathering process.

#### **3.2.1 INTERVIEWS**

According to Yeung (2010), interviews are a formal face to face meeting carried out between 2 or more individuals for the purpose of gathering information. Interviews conducted were targeted at the plant manager and production clerks. The focus of the interviews was to find out how the current system functions and find out who the different users are and how they relate to it. This was done in January at Mega Pak offices in Ruwa.

##### **a) Advantages**

- ❖ A better insight was obtained on how the current system works from the detailed information gathered
- ❖ The plant manager and production clerks were able to properly express themselves and rephrase their sentences where appropriate.
- ❖ By enabling the users to be able to freely express themselves and allowing the interviewer to clarify grey areas accurate information was obtained.
- ❖ The use on non-verbal cues added more meaning to what was being said.

## **b) Disadvantage**

- ❖ In order to put the organization in good light some employees gave biased and conflicting information.
- ❖ Time was a scarce resource when conducting interviews with production clerks as they had a lot of work to be done.
- ❖ Interviews were not able to capture a large audience, thereby limiting the researcher's ability to gather more information.

### **3.2.1.1 RESULTS**

After conducting the interviews, it was discovered that both the plant manager and production clerks complain about the limitations of the current system. They raised issues to do with the slowness of the system, data inaccuracy and lack of informative reports. The plant manager pointed out to the need of a web based system for flexibility and in order to produce meaningful reports to present to the executive managers.

### **3.2.2 OBSERVATION**

According to Sapsorn and Jupp (2006) an observation is a method that enables individuals to gather first hand data regarding the operations and processes by witnessing or viewing the process taking place. All process inputs and outputs of the present system were observed. This was done in January at the Mega Pak offices in Ruwa. Important observations include:

- ❖ Taking note of OEE variable i.e. downtime, number of rejects and total output
- ❖ Computing of daily OEE
- ❖ Searching OEE of a particular time
- ❖ Creating trends of OEE on a weekly basis
- ❖ Creating reports of OEE movement to see changes over time.
- ❖ Notifying the plant manager of increasing OEE
- ❖ Raising suggestions of lowering OEE

## **a) Advantages**

- ❖ Observations did not disrupt work flow at the organisation especially for the production clerks that had a huge workload
- ❖ Less costs were involved compared to the other methods, especially stationary costs
- ❖ Bias was eliminated hence improving the validity of the gathered information
- ❖ The researcher was able to anticipate unlikely outcomes from the system

## **b) Disadvantages**

- ❖ Since employees knew that they were being observed they may have altered their behavior which would have resulted in biased results.
- ❖ Some processes occur occasionally such as yearly OEE trending could not be observed.
- ❖ Observations did not help in answering the question why certain observed behaviours or processes occur.

### **3.2.2.1 RESULTS**

It was observed that production clerks took a very long time searching for the OEE of a particular machine for a particular period of time. The plant manager also faced difficulties in producing meaningful reports about the weekly OEE to present to executive management. The production clerks had to physically notify the plant manager and give him the captured information concerning OEE. Due to inaccuracy in information regarding OEE over long periods of time management could not make an informed decision about whether to keep or dispose a particular machine. The plant manager is always moving around the plants and is rarely in his office, and is incapacitated to accessing OEE information and make real-time decisions.

### **3.2.3 QUESTIONNAIRES**

A questionnaire is a series of questions asked to a particular targeted group of people with the intention of gathering data and answer questions related to a research topic (Sapsford and Jupp, 2006). They are relatively simple to administer to a large audience. Both open ended and close ended questions make questionnaires effective and not monotonous to answer. Close ended questions are easy to answer where the respondent simply ticks the appropriate answer while open ended questions require a short narrative. Ample time was given to respondents to answer the questionnaire. Questionnaires were given to the plant manager, production clerk and machine operators who took them home and answered at spare and free time. Questionnaires were given to employees who work in the production department and executive management.

## **a) Advantages**

- ❖ Due to anonymity respondents usually give an honest answer.



- ❖ Less time was consumed answering questions since some were close ended and simple to answer.
- ❖ Properly structured and well expressed answers were returned.
- ❖ Questionnaires helped target a larger audience such as stock controllers where production clerks request stationary.
- ❖ Work flow was not disrupted since answering was done during spare and free time.

#### **b) Disadvantages**

- ❖ Failure to capture non-verbal cues
- ❖ There was no room to clarify ambiguous answers
- ❖ Some questions returned poorly answered
- ❖ Uncertainty of who answered the question may compromise the validity of the information obtained

### **3.3 ANALYSIS OF THE EXISTING SYSTEM**

The system being currently used to evaluate OEE involved a lot of manual work. For each factory availability and performance are recorded by the production department and quality is recorded by the quality department. The production clerks then collect all values from the two departments and begins to calculate OEE per machine for the previous day. After calculating OEE per machine they then calculate OEE for the factory. The production clerks then send this information to the production manager. The production manager then calculates the OEE for the whole organization for the previous day and begins to create reports for each machine, factory and the organization as a whole. Reports include OEE trends done on the first day of the week. Deriving from the OEE reports the manager gives suggestions on how to increase the OEE. The designed reports are presented to executive management on every Tuesday. Management then directs corrective action to taken.

Tallant (2011) defined process analysis as a thorough review of all aspects of a process in the hope of improving its operations in regards to cost, speed and quality. Inputs, processes and outputs are the main activities carried out.

#### **a) Current system inputs**

- ❖ Quality details

- ❖ Performance details
- ❖ Availability details
- ❖ Factory details
- ❖ Machine details
- ❖ Downtime details

**b) Current system processes**

- ❖ Calculation of daily OEE
- ❖ Calculation of weekly OEE
- ❖ Calculation of monthly OEE
- ❖ Calculation of yearly OEE
- ❖ Calculation of quality
- ❖ Calculation of availability
- ❖ Calculation of performance

**c) Current system outputs**

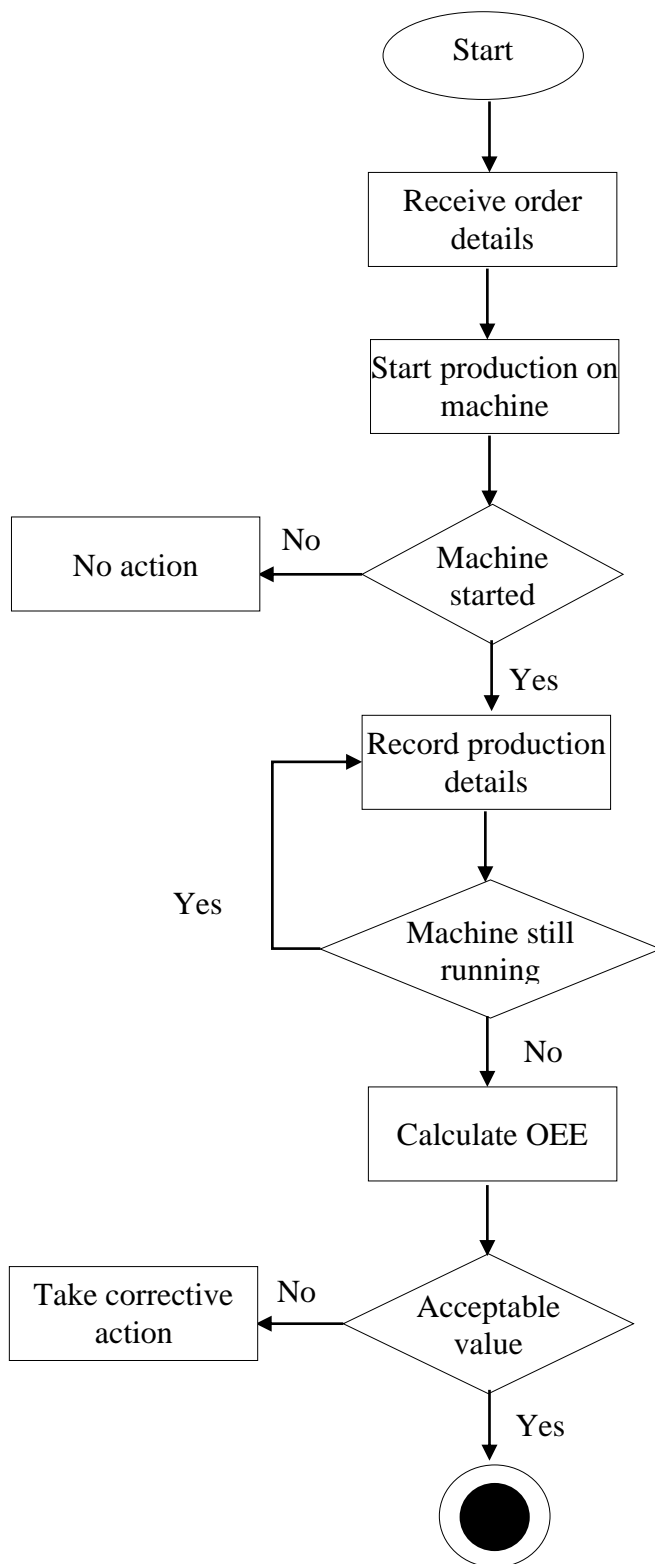
- ❖ Machine availability percentage
- ❖ Machine performance percentage
- ❖ Machine quality percentage
- ❖ Daily, weekly, monthly and yearly OEE
- ❖ Suggestion to increasing OEE
- ❖ Trends of OEE

### **3.4 PROCESS ANALYSIS**

Process analysis is the systematic evaluation of the steps involved in converting inputs into outputs and the activities in-between (Sommerville, 2011). It shows the order of activities, processes, decisions and data movement along the whole process. It is used to show the sequence of related processes and activities involved in the conversion of inputs into meaningful outputs within the current system.

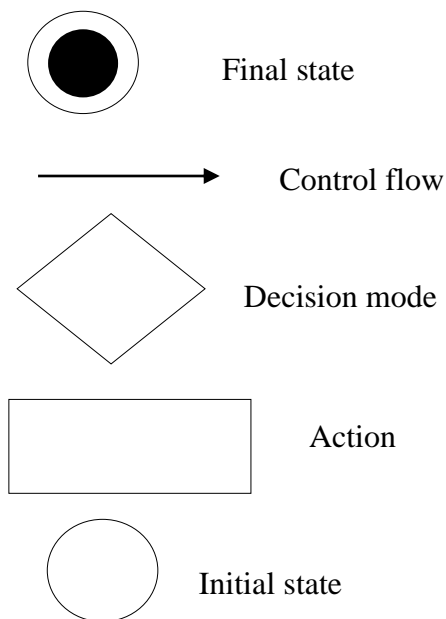
#### **3.4.1 ACTIVITY DIAGRAM**

According to Sommerville (2011), an activity diagram shows the chronology of activities and events within a system. It shows activities and actions with accompanying iteration and choice. Fig 3.1 outlines the activity sequence Mega Pak's OEE system.



**Fig 3.1: Activity diagram**

## Key

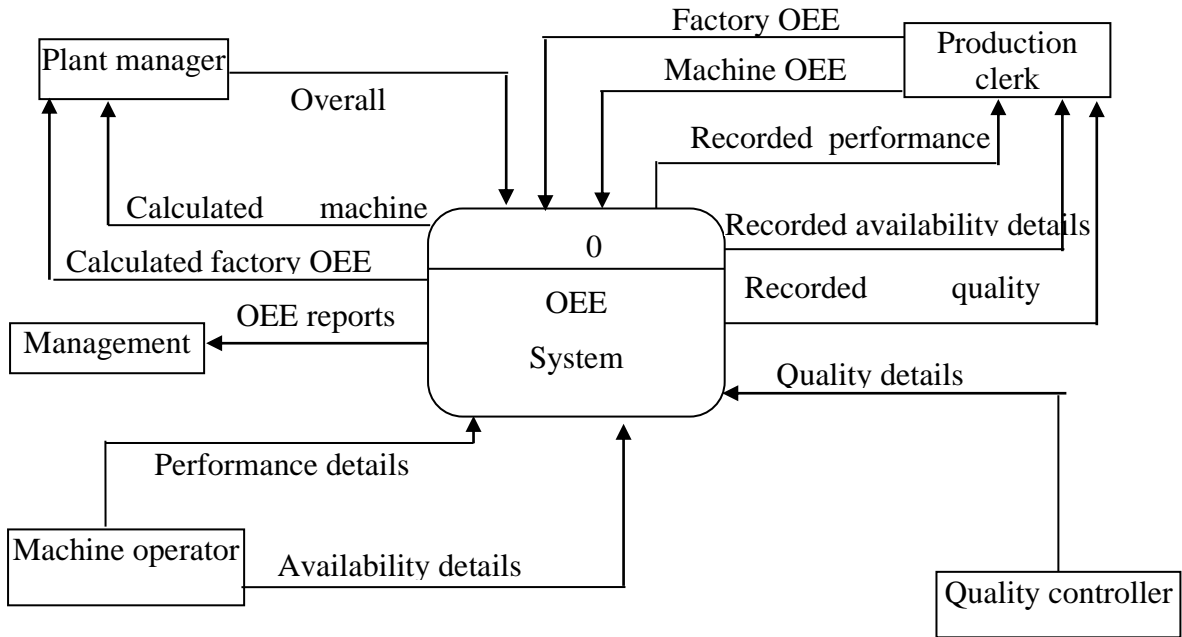


### 3.5 DATA ANALYSIS

Data analysis is aimed at discovering useful information by modelling, inspecting and transforming data (Sighn, 2007). Dataflow diagrams (DFDs) and context diagrams are used to analyse the data flowing in the current system. Data is clearly presented and processes are arranged in a chronological manner. DFDs and context diagrams illustrate a chronological flow of data and the different processes involved in transforming this data.

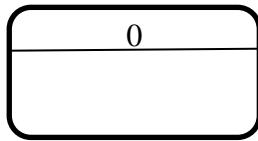
#### 3.5.1 CONTEXT DIAGRAMS OF THE CURRENT SYSTEM

Context diagrams show the boundaries between a system and its environment with the entities it interacts with (Sighn, 2007). It is simple and shows the generalized flow of data within the system. All processes are combined and entities interact with it.



**Fig 3.2: Context diagram of the current system**

**Key**



Process



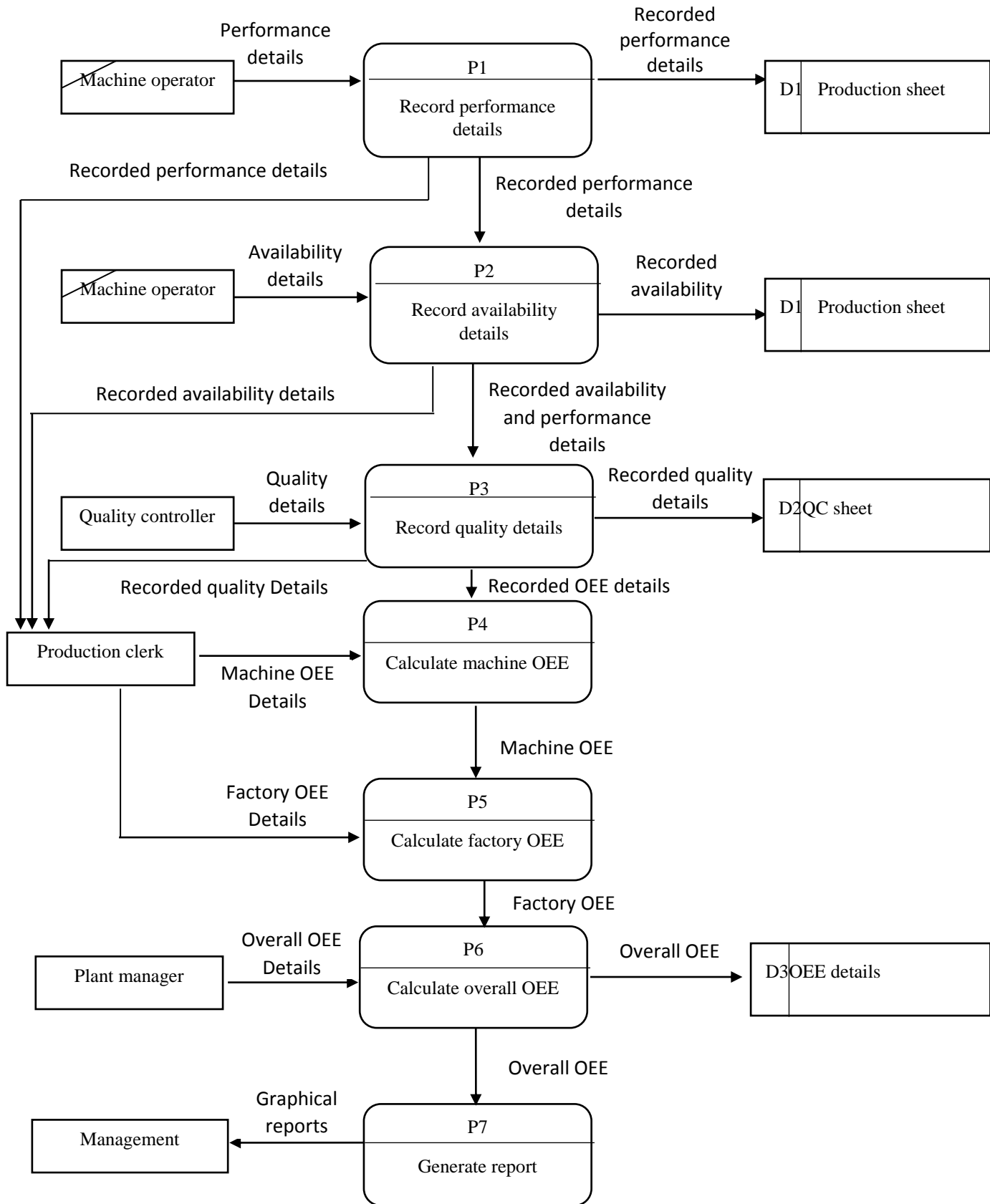
Entity



Data flow

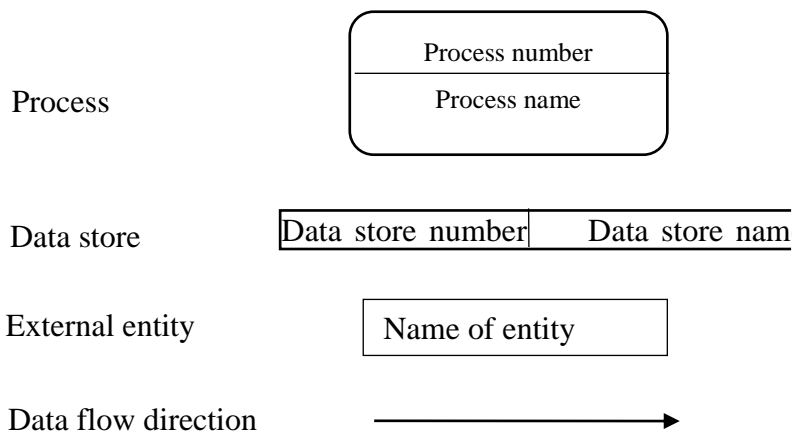
**3.5.2 DATA FLOW DIAGRAM OF THE CURRENT SYSTEM**

According to Hathaway and Hathaway (2016) a DFD maps out the flow of data within a particular system. It gives a graphical representation of entities from which data flow from to processes which manipulate the data to provide output which is stored data stores or given to another or entity.



**Fig 3.3: Data flow diagram for the current system**

## Key



### 3.6 WEAKNESS OF THE CURRENT SYSTEM

- ❖ Processes in the current system are labour intensive. Production clerks have to spend a huge amount of time calculation the OEE for each machine and the factory as a whole.
- ❖ The current system is also painstakingly slow. It takes a huge period of time from recording OEE variable to calculation the OEE and create reports.
- ❖ A lot of stationary cost are incurred in the current system. Production sheets have to be duplicated making the other copy for the production clerks to use.
- ❖ Record keeping is poor. Records take up a lot of space so that they can be used in the future.
- ❖ The current system lacks data security. Anyone with access to the production clerk's office can access all information regarding the organization OEE.
- ❖ If the production sheets were to be torn or lost they are difficult to trace and find since there is no proper backup of data.
- ❖ Manual calculation of OEE leads to a high degree of human error. Input and miscalculation error become common
- ❖ OEE management is difficult if it cannot be accessed by the plant manager in real-time as he is often moving around the different plants.
- ❖ Lack of notification means that production clerks may fail to notify the plant manager that the OEE is raising resulting in no corrective measures being taken.
- ❖ The lack of query capacity makes it difficult for the users to query for atomic values.

### **3.7 EVALUATION OF ALTERNATIVES**

In creating an alternative solution to counter the weaknesses of the present system three approaches were considered. These being development, outsourcing and improvement. Each will be considered in turn before the developer arrives at a decision on which one is most suitable for this project.

#### **3.7.1 OUTSOURCING**

Shore and Chromatic (2007) assert that outsourcing refers to the practice of hiring an external organisation or individual to develop a system for the organisation. The organisation approached different software development companies with their problem who then in turn produce a quote and provide supporting infrastructure to resolve the problem. An external developer might fail to comprehend the main thrust being pursued by Nampak South Africa regarding Operational Excellence (OPEX).

##### **a) Advantages**

- ❖ Superior quality applications can be produced since the contracted organization usually specializes in software development
- ❖ The application is produced in the shortest possible amount of time since it is not profitable to dwell on the same project for a long period of time.
- ❖ There is room for new ideas since the organizational culture and problem solving techniques are different among the organizations.

##### **b) Disadvantages**

- ❖ Cost may increase in the future as a result of maintenance and updating costs
- ❖ Develops from another organization may fail to fully comprehend the nature of the organization and its users.
- ❖ There is loss of management direct control on the development process
- ❖ There is risk of losing sensitive and confidential data.

#### **3.7.2 IMPROVEMENT**

According to Shore and Chromatic (2007), improvement is the process adding new features and removing bugs and inefficiencies from the current system. In relation to the current system improvement that can be done include designing templates for OEE calculation. This



might be faster than the present way of doing things but would still be slow and prone to multiple errors inherited from the previous system.

**a) Advantages**

- ❖ It is cost effective since it does not require the purchase of additional equipment.
- ❖ Easy to learn as employees are already familiar with how the current system operate.

**b) Disadvantages**

- ❖ No major change is achieved since the system continues to be manual and prone to many errors.
- ❖ Bugs and inefficiencies from the old system are carried onto the improved system.

**3.7.3IN-HOUSE DEVELOPMENT**

According to Shore and Chromatic (2007), in-house development is an approach where the organisation’s employees use the organisations resources in the development of a suitable system.

*Table 3.1: In-house development costs*

	Cost (\$)
Development costs	\$4900

Table 3.1 is an extract of table 2.5 showing the total development costs.

**a) Advantages**

- ❖ This results in full ownership and control of the application solution
- ❖ Less extra costs are incurred in maintaining and upgrading the system
- ❖ The developers fully appreciated the nature of the organization and its users
- ❖ There is no risk in losing sensitive and confidential information to third parties

**b) Disadvantages**

- ❖ Employees within the organization may lack the adequate skills to produce a bug free program.
- ❖ Activities within the organization may delay the project completion time.

### 3.7.4 ALTERNATIVE SELECTION

After an in-depth analysis of the different software development approaches, the developer advocated for the use of in-house development. It is more suitable for this organisation since the system will be tailor made to fit the organisation and its user requirements. Since most off the shelf applications are made outside Zimbabwe they do not fully appreciate the nature of the Zimbabwe industry and the challenges it faces such as power outages which grossly disrupt production. User training will be less costly and yield better result since users will be trained by the people they know and feel free to ask questions for better understanding. Although improvement might seem cheaper it is not a desired alternative as the cost is greater in terms of bugs and errors. Giving the organisation control over their application benefits the organisation in that they do not need to annually subscribe for a license every year. Sensitive and confidential data is safeguarded from competitors as external organisations may great backdoors and intentional security pitfalls.

*Table 3.2: Alternative development costs*

Development alternative	Cost (\$)
Outsourcing	9000
Improvement	4500
In-house development	4900

### 3.8 REQUIREMENTS ANALYSIS

Guthrie et al (2011) explain that requirements analysis are the tasks involved in determining the needs of a proposed system. Its main focus is to address the weaknesses in the current system. These needs are subdivided into non-functional requirements and functional.

#### 3.8.1 FUNCTIONAL REQUIREMENTS

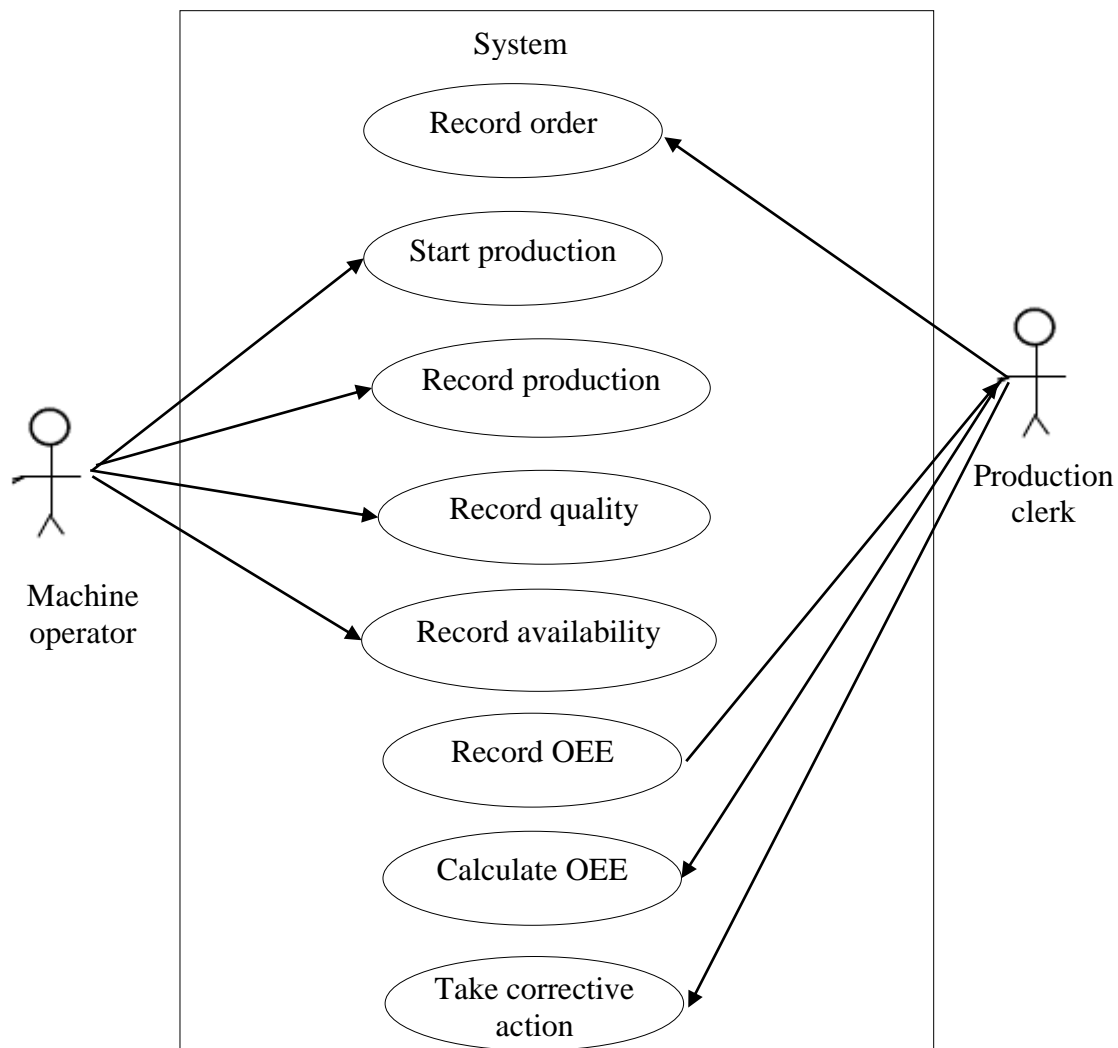
In software engineering, functional requirements define the inputs, outputs and process of a proposed system (Guthrie et al, 2011). They define the boundaries of a system and describe what the system is supposed to perform.

##### a) Functional requirements include:

- ❖ Calculate overall machine and factory OEE on a daily, weekly, monthly and yearly basis

- ❖ Notify plant manager using an SMS when OEE levels drop below organization standard
- ❖ Explain to the plant manager possible causes of decreasing OEE levels
- ❖ Backup all transactions on daily, weekly and monthly basis to an external server
- ❖ Show trends of OEE for different period e.g. week, month
- ❖ Record all OEE variables from the production and quality sheets
- ❖ Print A3 size reports on a weekly and monthly to display in the situation room

### 3.8.1.1 USE CASE DIAGRAM



*Fig 3.4: Use case diagram*

### 3.8.2 NON-FUNCTIONAL REQUIREMENTS

Guthrie et al (2011) agreed that non-functional requirements put certain constraints regarding the system behaviour, these constraints describing how the system works. They can be

described as the quality attributes of a system. They govern behaviour such as what kind of input can be accepted by the system e.g. integers

**a) Non-functional requirements examples:**

- ❖ Authorization – Usernames and password are used to verify authentic users.
- ❖ System backup – The system should perform back on a weekly basis or when prompted by the user.
- ❖ User interface – User interfaces should be easy to navigate and interactive.
- ❖ Database – Only atomic values of the correct type should be accepted into the database.
- ❖ User access – Different access levels should be enforced to make users access what they should

### **3.9 CONCLUSION**

This chapter took a look at the advantages and disadvantages of the different data gathering techniques. A context diagram and DFD were used to analyse the flow of information in the current system. After analysing the weakness of the present system it was noticed that there was need to develop a new system. Alternative solutions proceeded soon after in which in-house development was viewed as the most suitable development method. The following chapter, focuses more on the proposed system. It will tackle issues to do with the architectural, physical and database design.

## **CHAPTER FOUR: DESIGN PHASE**

### **4.1 INTRODUCTION**

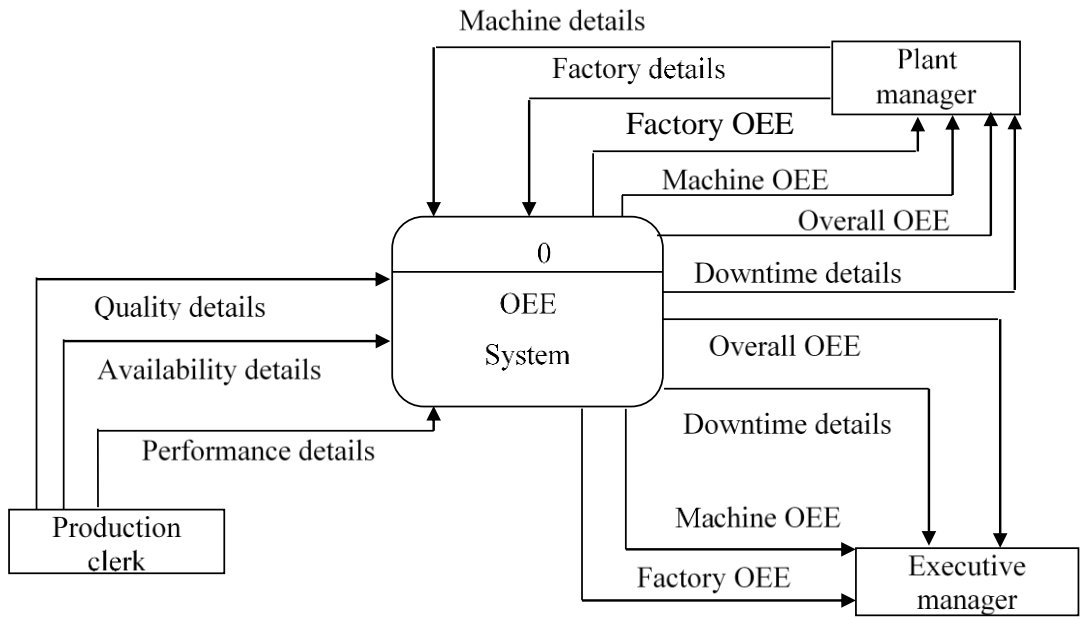
The previous chapter looked at the different information gathering techniques, dataflow diagram of the proposed system and evaluation of alternatives. The design phase look at different aspects of the proposed system. It takes a look at database design, interface design, physical design and architectural design of the proposed system. A context diagram and dataflow diagram will be used to show the flow of data in the proposed system. Pseudo code will be written to form a basis of the actual code to be written. At the close of this chapter the security design of the proposed system is addressed. Issues to do with preventing unauthorized access will be addressed in the security design.

### **4.2 SYSTEM DESIGN**

According to Saltzer and Kaashoek (2009), system design involves the tasks of defining a system's interfaces, components, modules, architecture and data in order to satisfy user requirements. The proposed system should be efficient and effective in satisfying user requirements at the same time providing security for confidential information. The proposed system should include the following functions: view historic data regarding the organization's OEE, notify the plant manager of rising OEE levels, allow communicate between clerks and the production manager, and generate reports. Modules will be interconnected in order to permit ease of operation and sharing of information. In order to show the flow of data within the system a context diagram and dataflow diagram will be used.

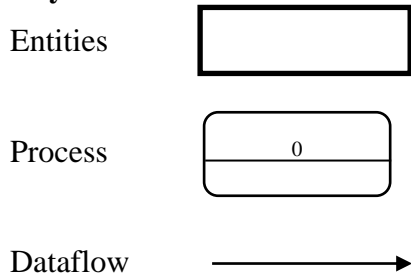
#### **4.2.1 CONTEXT DIAGRAM OF THE PROPOSED SYSTEM**

A context diagram outlines the boundaries that exists between the proposed system and its environment showing the entities it interacts with (Grandy, 2010). A central process is shown and the entities it is linked to into which data flow into and out of. It is a compressed DFD.



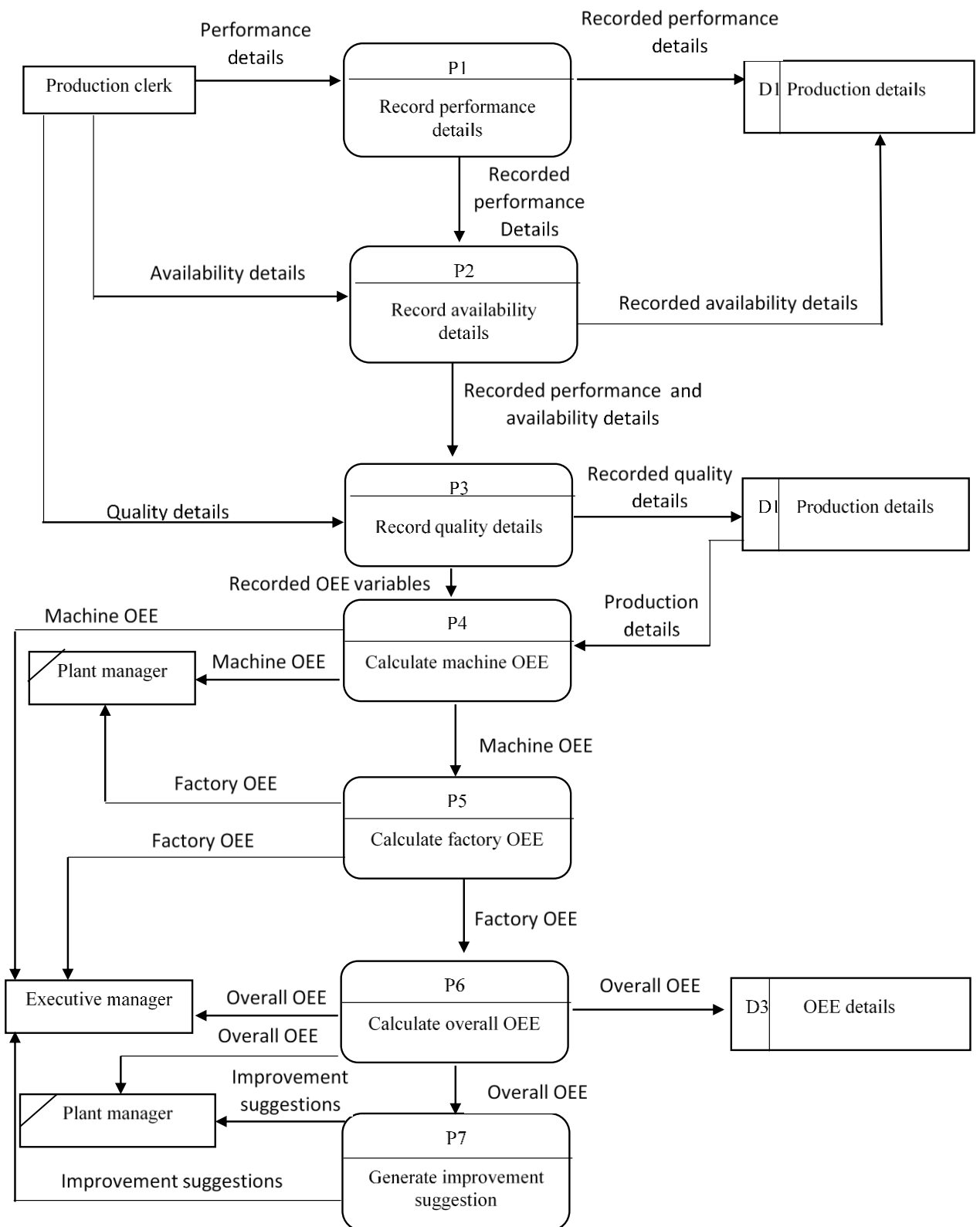
*Fig 4.1: Context diagram of the proposed system*

**Key:**



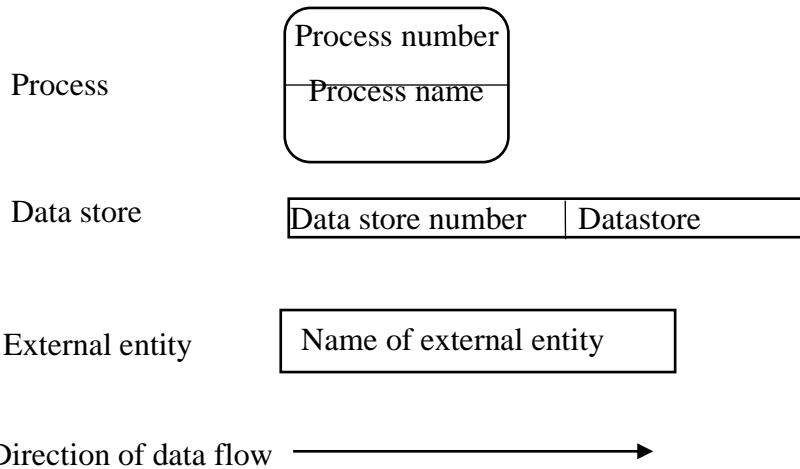
**4.2.2 DATAFLOW DIAGRAM OF THE PROPOSED SYSTEM**

According to Tilley and Rosenblatt (2016), a DFD shows how data flows within a particular system. It is particularly important in system modelling when every entity, process and data store of a system are considered. Entities provide or data stores provide input into process which changes it to output which is forwarded to other process or data stores or entities.



**Fig 4.2: Dataflow diagram of the proposed system**

## Key



### 4.3 ARCHITECTURAL DESIGN

Architectural design refers to way in which data and program modules are organized in order to create a computerized system (Argarwal and Tayal, 2009). In addition, Khurana (2009) says that it is the initial blueprint used for software development. It outlines all infrastructure, hardware and software necessary for a system to function. It represents a high level design of the software program and provides a level of abstraction where the software engineer may specify the system behaviour. It is the way in which data is arranged in the database in layers called schemas. A database schema comprises of three layers; application layer, physical layer and conceptual layer.

#### Hardware and software requirements

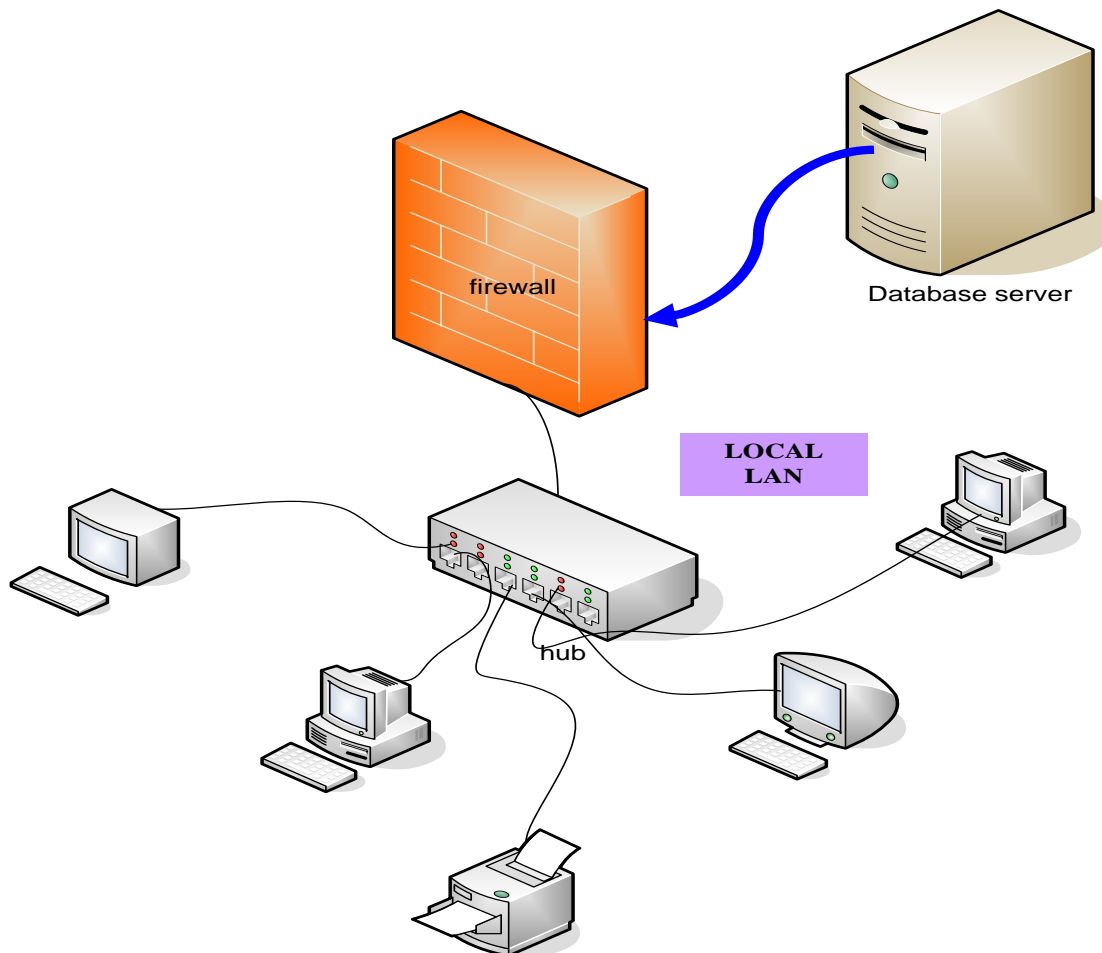
- a) Database server
  - ❖ HP 800 desktop
- b) Workstation
  - ❖ HP GMT 280 business pc
- c) Printer
  - ❖ HP LaserJet 750

### 4.4 PHYSICAL DESIGN

Keyes (2002) highlights that physical design is the process of planning the actual implementation of the system. It defines the mapping out of the components of the proposed



system. It focuses on the network layout and the interaction between servers and nodes, this is the connection of machines, database server and printer to be used by employee at Mega Pak Zimbabwe. Mega Pak already has some existing infrastructure in place, except a few items like the database server, and printer.



*Fig 4.3 Physical design of the proposed system*

#### **4.4.1 SOFTWARE AND HARDWARE REQUIREMENTS**

##### **DATABASE SERVER**

- ❖ Processor – Inter core i3 3.60 GHz
- ❖ RAM – 4GB
- ❖ System type – 64-bit operating system
- ❖ HDD – 00GB
- ❖ Network card – 10/100 mbps
- ❖ DVD / CD drive – 52x read, 24x write

### CLIENT MACHINE

- ❖ Processor – Intel dual core 2.5 GHz
- ❖ RAM – 2GB
- ❖ HDD – 500GB

### NETWORK

- ❖ 8 port CISCO switch
- ❖ TP-Link wireless access point

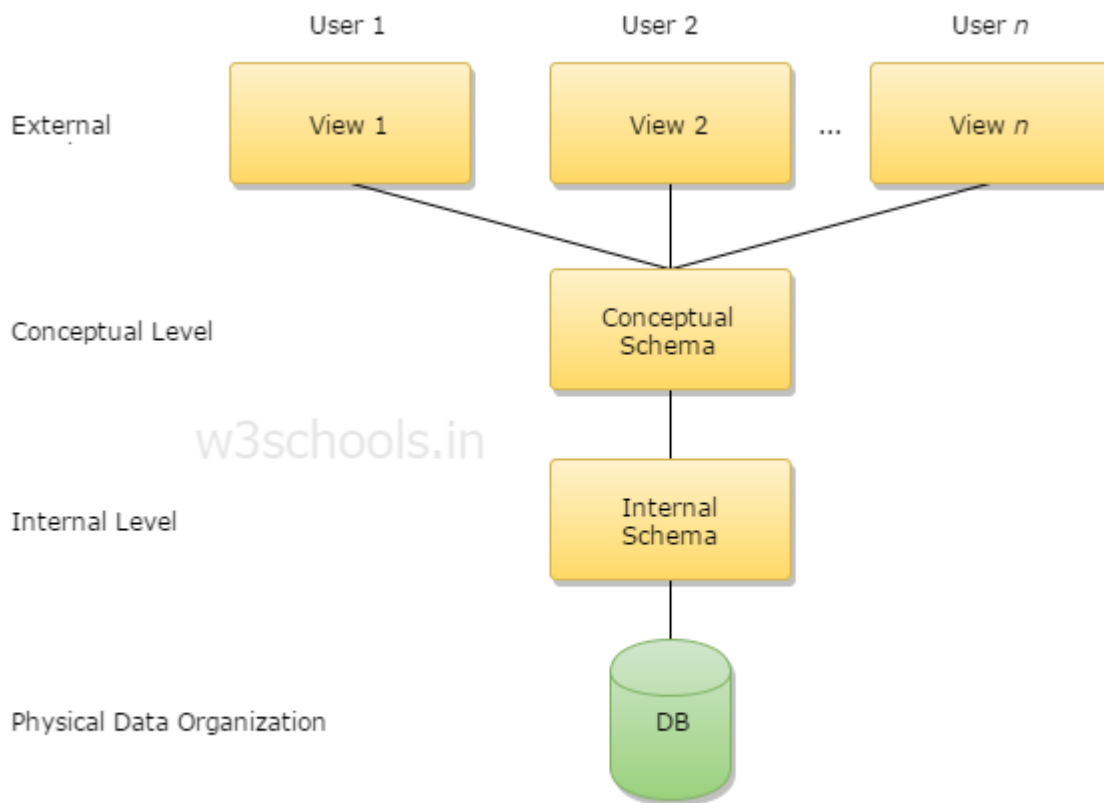
### SOFTWARE

- ❖ Windows 8 Professional
- ❖ MySQL server 2016
- ❖ XAMPP
- ❖ Macromedia Dreamweaver 8

## **4.5 DATABASE DESIGN**

Powell (2006) explains that database design involves all activities undertaken to design and create a data model of a functional database. A typical database houses a collection of related data. The design of any database solemnly depends on the data to be stored in it. To ensure the consistency of the database at all times it is necessary to put in place integrity constrains. It is important to ensure that tables in the database are normalize up to 3NF (Stephens and Plew, 2000). Input forms are used to gather data from users and store it in a database.

Stephens and Plew (2000) also point out the importance of the database schema as it refers to the set of rules that govern a database. It comprises of three hierarchical and independent layers. Adjacent layers are not affected with changes that occur in one. As shown in Fig 4.3, the ANSI-SPARC conceptual model was used and the model consists of three layers.



ANSI\_SPARC Architecture of the database system

**Fig 4.4: ANSI-SPARC conceptual model**

The ANSI-SPARC architecture levels each perform a different.

**a) External level**

Singh (2009) says that this is the highest level of abstraction and it allows users to interact with the database. It allows users to interact with part of the database. It shows the users relevant information for which they have access to. Different users have different view depending on their access level and main area of focus at any particular time.

**b) Conceptual level**

Conceptual level also referred to as the logic level describes the data stored in the database and the relationship among it (Singh, 2009). It does provide integrity constrains for the data. This level does not however mention how the data is physically stored. It hides the complexities of the physical storage and application developers operate at this level

### c) Internal level

Singh (2009) points out that this layer specifies how data is physically stored on a computer system. It is the lowest level of data abstraction. It deals with data encryption, data compression, file structures, complex low level data structures, and access methods among others in details

#### 4.5.2 TABLE DESIGN

*Table 4.1: Login*

Fieldname	Data type	Description
Id	Int(3)	PRIMARY KEY, AUTO_INCREMENT, NOT NULL
Username	Varchar(50)	NOT NULL
Password	Varchar(50)	NOT NULL
access_level	Int(3)	NOT NULL

*Table 4.2: Machine details*

Fieldname	Data type	Description
Mid	Varchar (50)	PRIMARK KEY, NOT NULL
Name	Varchar(50)	NOT NULL
Model	Varchar(50)	NOT NULL
Location	Varchar(50)	NOT NULL
date_purchased	Date()	NOT NULL
useful_life	Int(3)	NOT NULL
purchase_price	Int(10)	NOT NULL
residual_value	Int(10)	
product_line	Varchar(50)	NOT NULL
cycle_time	Double(8)	NOT NULL
Fid	Int(10)	NOT NULL

*Table 4.3: Products*

Fieldname	Data type	Description
PID	Int(8)	PRIMARY KEY, AUTO_INCREMENT
Name	Varchar(50)	NOT NULL
Specification	Varchar(100)	

**Table 4.4: production details**

Fieldname	Data type	Description
Id	Int(8)	PRIMARY KEY, AUTO_INCREMENT, NOT NULL
Fid	Varchar(50)	NOT NULL
Mid	Varchar(50)	NOT NULL
Availability	Varchar(50)	NOT NULL
Performance	Varchar(50)	NOT NULL
Product	Varchar(50)	NOT NULL
batch_no	Varchar(50)	NOT NULL
Date	Timestamp	
operator	Varchar(50)	NOT NULL

**Table 4.5: Quality details**

Fieldname	Data type	Description
Id	Int(8)	PRIMARY KEY, AUTO_INCREMENT
Fid	Varchar(50)	NOT NULL
Mid	Varchar(50)	NOT NULL
Product	Varchar(50)	NOT NULL
qc_rep	Varchar(50)	NOT NULL
date_produced	Date()	NOT NULL
date_checked	Date()	NOT NULL
batch_no	Varchar(50)	NOT NULL
Sample	Int(8)	NOT NULL
Defects	Int(8)	NOT NULL

**Table 4.6: OEE details**

Fieldname	Data type	Description
Id	Int(8)	PRIMARY KEY, AUTO_INCREMENT
date	Date()	
Machine	Varchar(50)	NOT NULL
Factory	Varchar(50)	NOT NULL
Period	Date()	
Oee	Double(8)	NOT NULL

**Table 4.7: Employee details**

Fieldname	Data type	Description
EID	Int(3)	PRIMARY KEY, AUTO_INCREMENT, NOT NULL
Name	Varchar(50)	NOT NULL
DOB	Varchar(50)	NOT NULL
Department	Varchar(50)	NOT NULL
Address	Varchar(50)	
Contact_number	Int(15)	

**Table 4.8: Factory details**

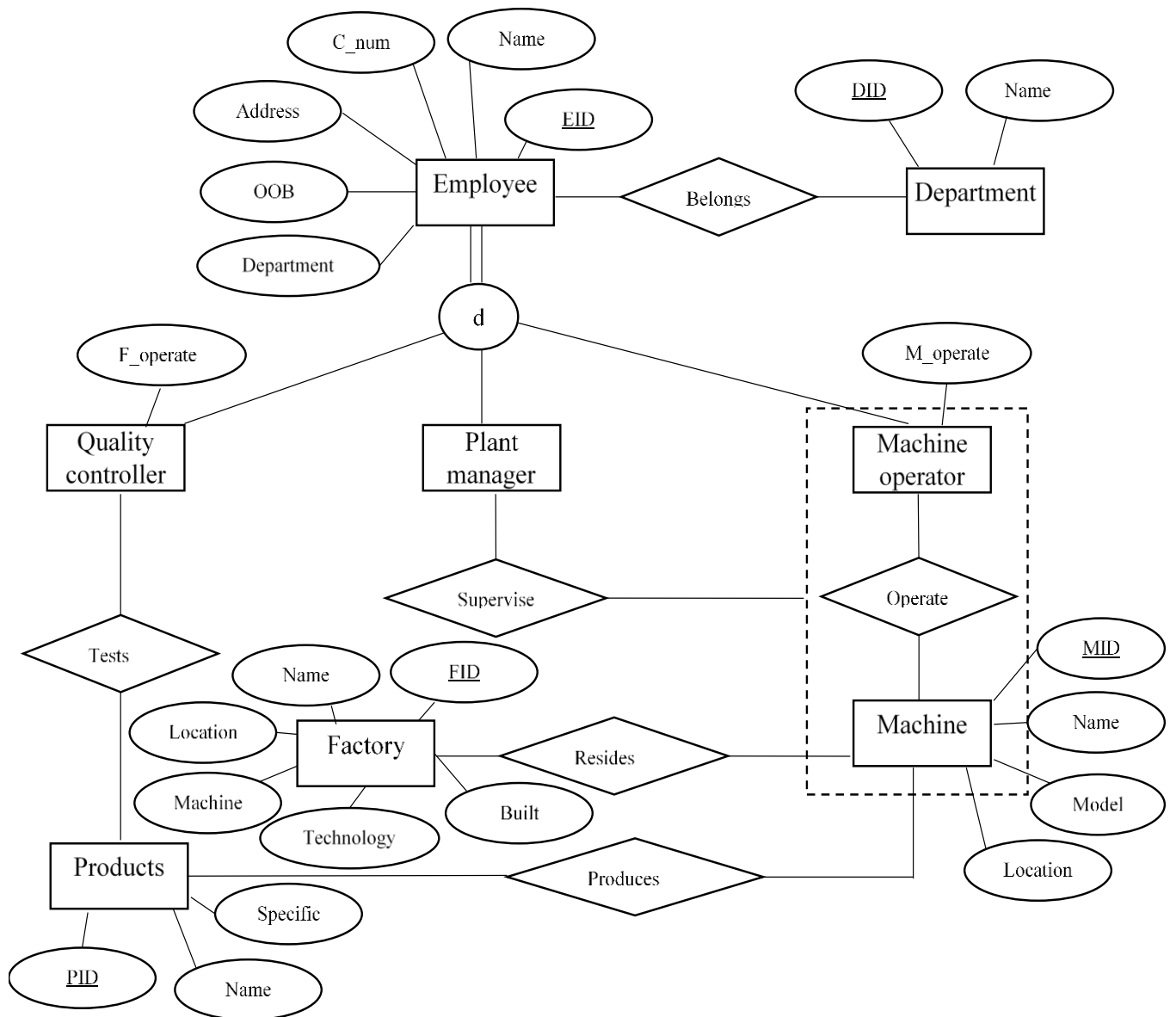
Fieldname	Data type	Description
Fid	Varchar(50)	PRIMARY KEY, NOT NULL
Name	Varchar(50)	UNIQUE, NOT NULL
Location	Varchar(50)	NOT NULL
Machines	Varchar(50)	NOT NULL
Technology	Varchar(50)	NOT NULL
date_built	Date()	NOT NULL

**Table 4.9: Department**

Fieldname	Data type	Description
DID	Int(8)	PRIMARY KEY, AUTO_INCREMENT
Name	Varchar(50)	NOT NULL

### 4.5.3 ENHANCED ENTITY RELATIONSHIP DIAGRAM (EER)

EER is a high level data model that clearly shows constraints and properties in a complex database (Sumathi and Esakkirajan). They go on to say that an EER is an extension of an entity relation (ER) model incorporation other concepts. Fig 4.5 is an EER diagram of the proposed system.



**Fig 4.5: EER diagram**

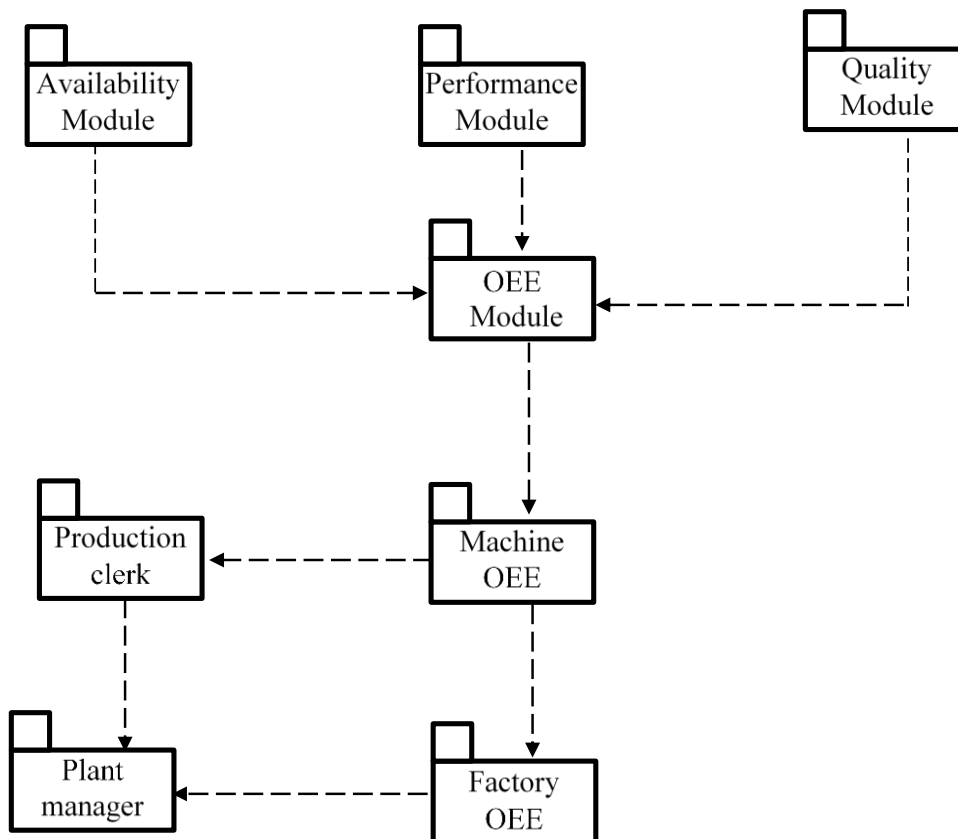
### 4.6 PROGRAM DESIGN

Program design is the process of identifying the necessary steps for the program to satisfy user requirements (Chiang, 2009). Every program is subdivided into modules. Unified

modelling languages (UML) which include packet diagrams are some of the tools used in designing the program.

#### 4.6.1 PACKAGE DIAGRAM

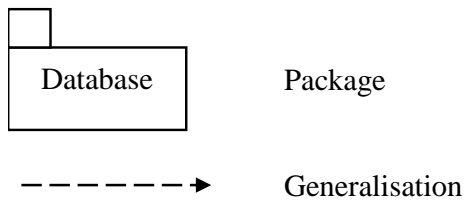
Chonoles and Schardt (2011) elaborate that packages are used to aid understandability of the different functions of the project. They generally show packages and how they are independent of each other.



**Fig 4.6: Package diagram**

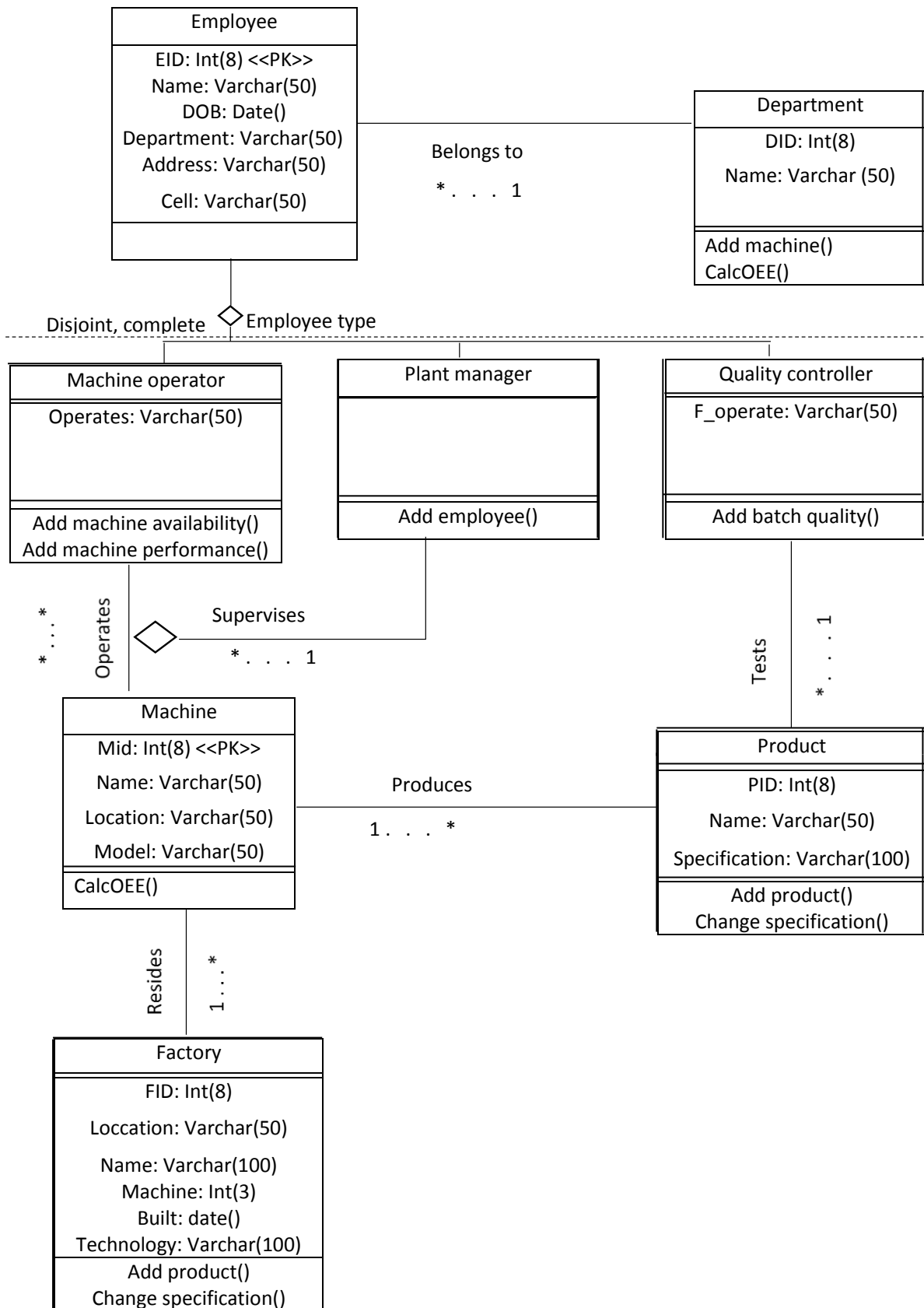


**Key:**



**4.6.2 CLASS DIAGRAM**

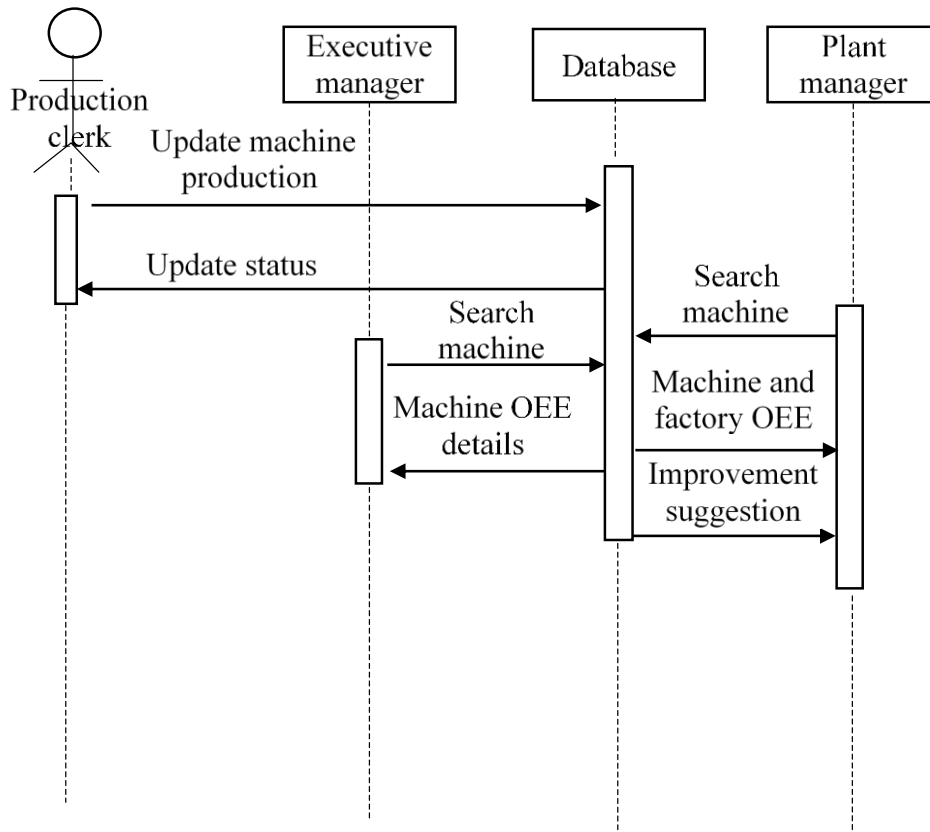
According to Favre (2003), a class diagrams shows classes interaction among themselves so as to enhance the systems functionality. It shows the behaviour and interaction of functions.



**Fig 4.7: Class diagram**

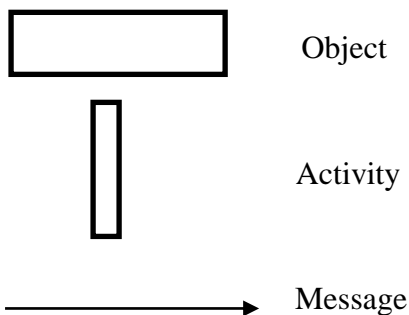
### 4.6.3 SEQUENCE DIAGRAM

Regarding sequence diagrams Favre (2003) says that they displays all objects that interact to achieve a particular goal. It shows the information that travels among objects in order for certain functions to be performed. The objects are shown in a timely and orderly manner.



*Fig 4.8: Sequence diagram*

**Key:**



## 4.7 INTERFACE DESIGN

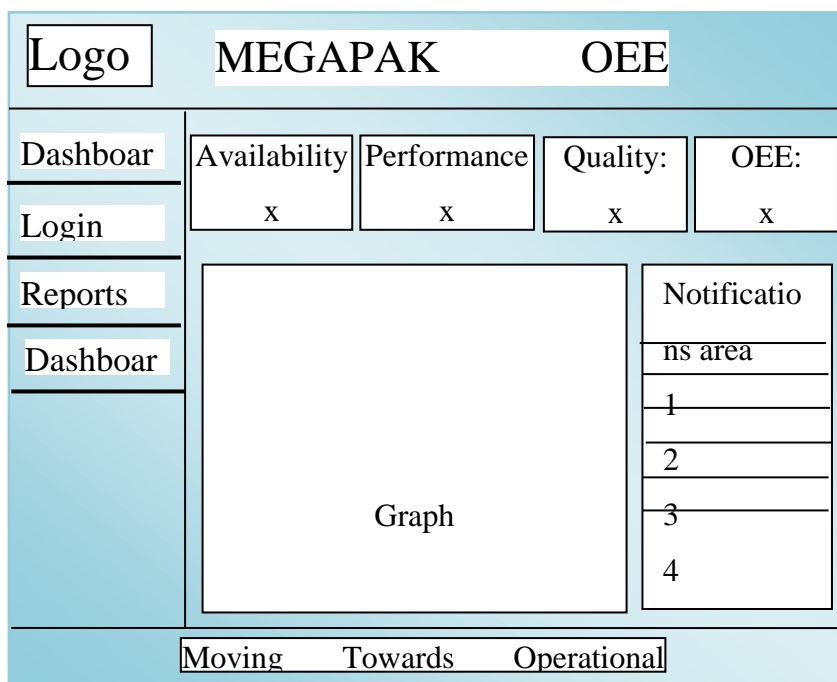
Interface design is the process of anticipating what the users want and creating the necessary tools for them to access them (Khurana, 2009). Simply put it is the designing modules that allow users to connect, share and exchange information. It creates pleasant system to user interaction. Interfaces may also serve for data entry and data validation. There are two main categories of interfaces mainly the graphical user interface (GUI) and the command line interface (CLI). In the GUI interface users interact with the system using buttons and using mouse clicks while in the CLI interface users use commands to interact with the system.

### 4.7.1 MENU DESIGN

Menu design is the designing of the main navigation pages for either the whole system or subsections.

#### 4.7.1.1 MAIN MENU

The main menu will be the first page that users will interact with as they start to interact with the system. It usually contains link to the main pages or important sections of the system. The main page is usually designed in such a manner that any user even without login credentials can this page.



**Fig 4.9: Menu design**

### 4.7.1.2 SUB MENUS

Sub-menus are available for each section and can be accessed after successful login.

Logo		PRODUCTION CLERK			
Add production	OEE TODAY				
Modify production	Availability x	Performance x	Quality: x	OEE: x	
Machine OEE	Graph			Top downtime	
Shift OEE				1	
Production updates				2	
Add downtime				3	
					4
Moving Towards Operational Excellence					

**Fig 4.10: Production clerk menu**

After successful logging into the system a production clerk can be add to add new production details, add production updates and downtime details.

Logo		PLANT MANAGER			
Machine OEE	OEE TODAY				
Factory OEE	Availability x	Performance x	Quality: x	OEE: x	
Shift OEE	Graph			Machines	
Manage users				Name – OEE	
Production				Name – OEE	
OEE reports				Name – OEE	
					Name – OEE
Moving Towards Operational Excellence					

**Fig 4.11: Plant manager menu**

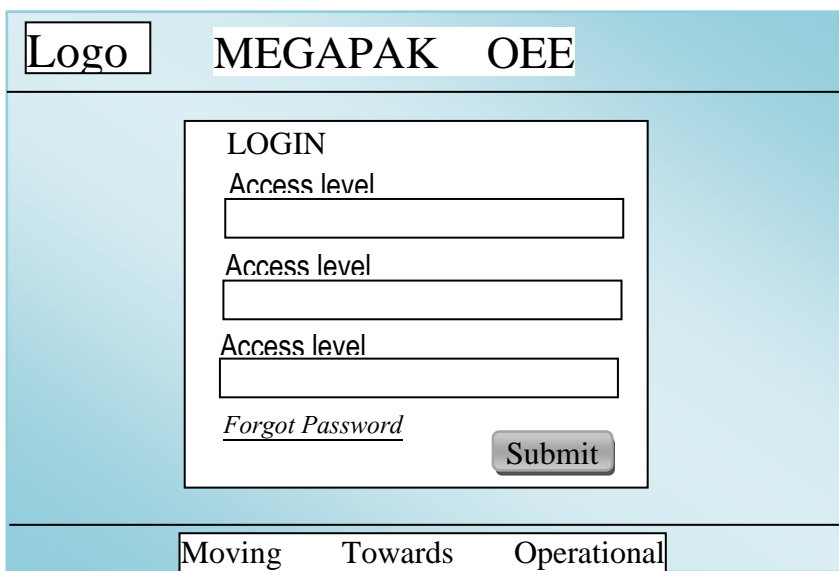
After successful login the plant manager has access to add new users and view customised OEE reports.

#### 4.7.2 INPUT DESIGN

Input forms are forms that allow users to give data and feedback to the system. For security reasons they are available to authentic users. They prevent people from playing around with the system. User input data is usually saved to a database or used to calculate or validate authentic users.

##### a) Security input design

The login page is used to authenticate users in order to grant them different access depending on their access levels. It also prevents unauthorized users from playing around with the system.



The image shows a web interface for a login form. At the top left, there is a box labeled 'Logo'. To its right, the text 'MEGAPAK OEE' is displayed. The main content area is a light blue rectangle containing a white box with the title 'LOGIN'. Inside this box, there are three input fields, each preceded by the text 'Access level'. Below the third input field is a link labeled 'Forgot Password'. To the right of the 'Forgot Password' link is a grey button labeled 'Submit'. At the bottom of the page, there is a footer with the text 'Moving Towards Operational'.

**Fig 4.12: Login form**

**b) Submission input forms**

Logo	MEGAPAK	OEE
Dashboard	Operator input form	
Login	Machine <input type="text"/>	<b>Variables</b>
Reports	Downtime <input type="text"/>	Performance
Dashboard	Cycle time <input type="text"/>	:
	Run time <input type="text"/>	----
	Comments	Availability:
	<input type="text"/>	---
	<input type="button" value="Submit"/>	
Moving Towards Operational Excellence		

**Fig 4.13: Operator page**

Only after successfully login can the operator access the form to input the different captured parameters to be used to calculate availability and performance. For compartmentalization and greater accuracy, other user levels are not allowed to access this page.

Logo	MEGAPAK	OEE
Dashboard	Quality controller	
Login	Batch <input type="text"/>	<b>Variables</b>
Reports	Sample size <input type="text"/>	Quality:
Dashboard	Defects <input type="text"/>	----
	Run time <input type="text"/>	
	Comment	
	<input type="text"/>	
Moving Towards Operational		

**Fig 4.14 Quality controller form**

The quality controller can input the captured details after performing various tests on the products in order to certify that the products are suitable for the market.

**Fig 4.15: Manage machines**

Only accessible to the plant manager this page gives him access to add, update and delete machine details. Proper validation will ensure that the correct format of data is captured. Only products that exist in the database can be deleted, hence the need to show an error message the product does not exist.

**Fig 5.16: Change password**



For security and confidentiality all users are allowed to change their login password at any given time. As shown in fig 5.16, they will need to provide their current password and the new password.

Logo	MEGAPAK	OEE
Dashboard	Manage user	
Login	<b>Add user</b>	<b>Update / delete user</b>
Reports	Username <input type="text"/>	Username <input type="text"/>
Dashboard	Password <input type="text"/>	Password <input type="text"/>
	Department <input type="text"/>	Department <input type="text"/>
	Employee <input type="text"/>	Employee <input type="text"/>
	<input type="button" value="Add"/>	<input type="button" value="Delete"/> <input type="button" value="Update"/>
Moving Towards Operational		

**Fig 5.17: User management**

User management is important in order to remove ghost works and ensuring that employee details are correct and up to date. It will only be accessible to the plant managed for reliability purposes.

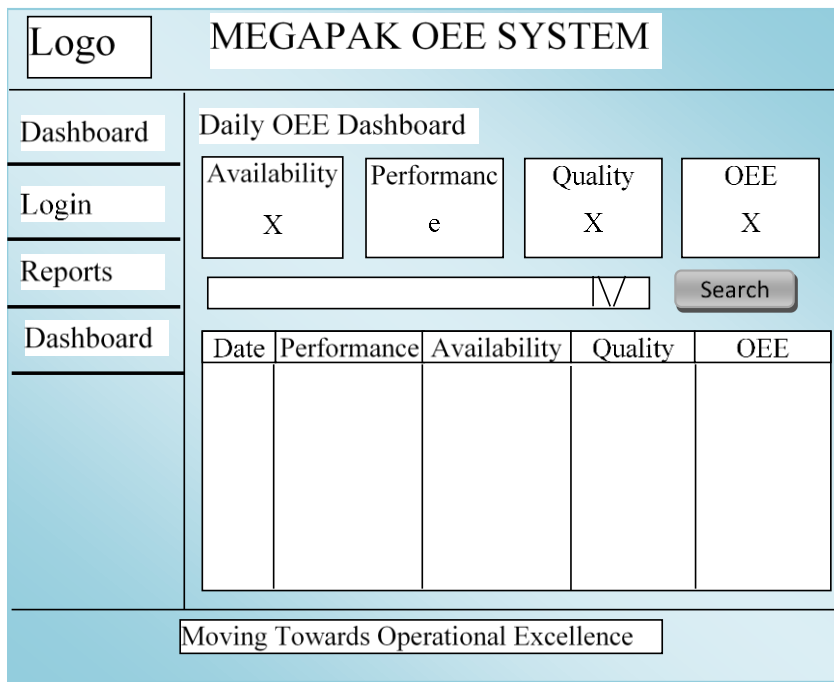
Logo		MEGAPAK		OEE	
Dashboard		Manage factories			
Login		Add factory		Update / delete	
Reports		Factory name		Factory name	
Dashboard		Location		Focation	
		Main		Main technology	
		Built amount		Built amount	
		Add		Delete Update	
Moving Towards Operational					

**Fig 4.18: Factory management**

Factory management form allows for the addition, removal and updating of factory details. This page will be accessible to the plant manager.

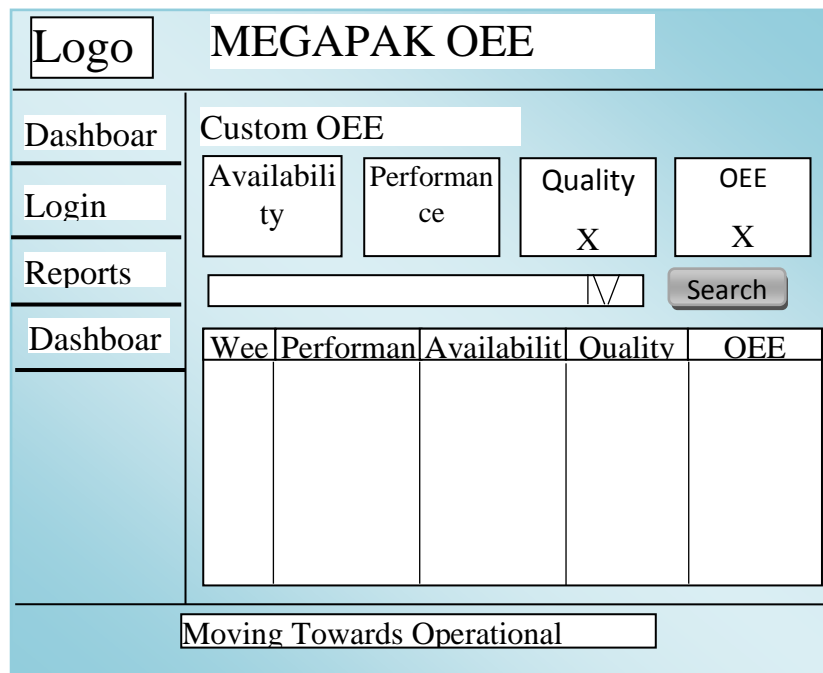
### 4.7.3 OUTPUT DESIGN

Output design forms help give feedback back to the user. They usually retrieve data from the database and present it to the user through the use of graphs and tables. They help track the organizations OEE at a micro level. This allows the users to view OEE per machine and factory. OEE can also be trended over periods of time. Information in output forms is being constantly updated to ensure that recent information is also available for analysis. Based on the OEE per machine and recommendations management can make a decision of whether the machine is still resulting in an overall improvement in the organization's financial position. The plant manager is able to view and track the 6 big losses common to production and take corrective action appropriately.



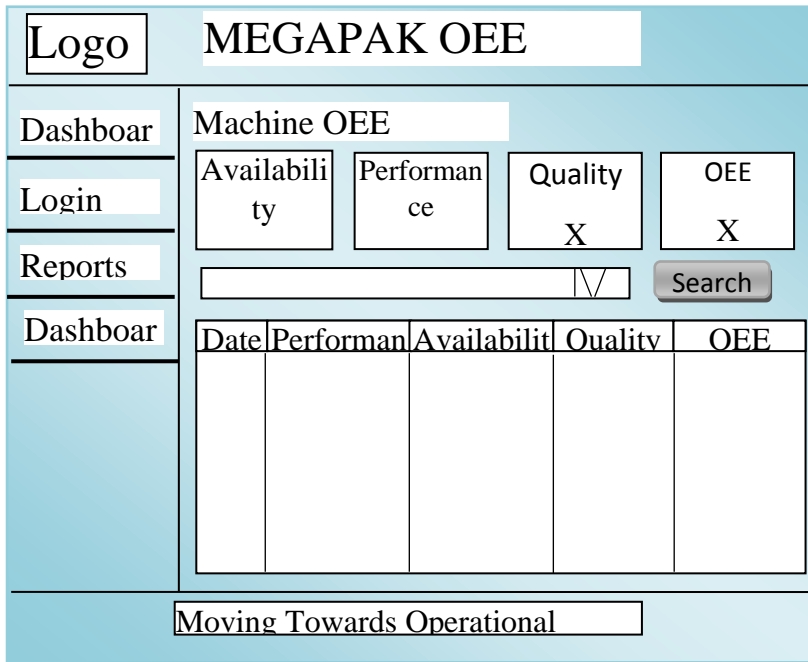
**Fig 4.19: Daily OEE dashboard**

The daily OEE dashboard allows users to keep real-time tracking of OEE levels. Input data is processed quickly and displayed as a dashboard. It can provide hourly OEE levels for each machine and factory.



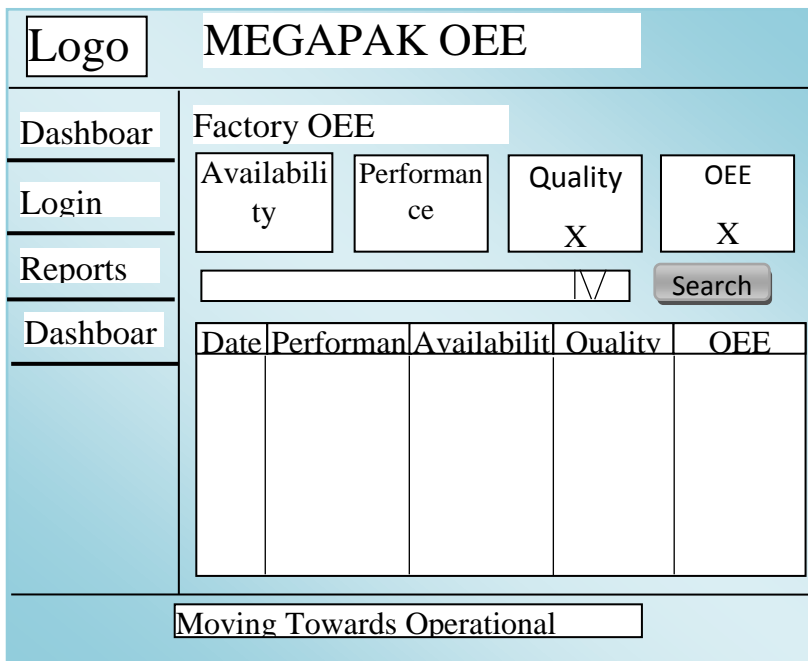
**Fig 4.20: Custom OEE dashboard**

Custom OEE dashboard allows the user to view the dashboard regarding OEE for a particular period of time. For example viewing the monthly, weekly or OEE for a particular date.



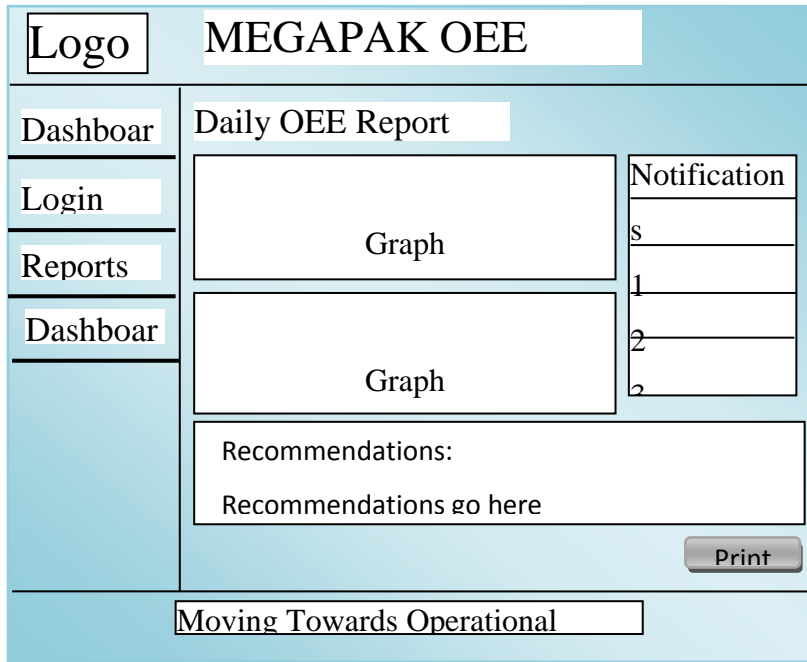
**Fig 4.21: Machine OEE dashboard**

Machine OEE dashboard allows the viewing of the OEE of a machine over a custom period of time.



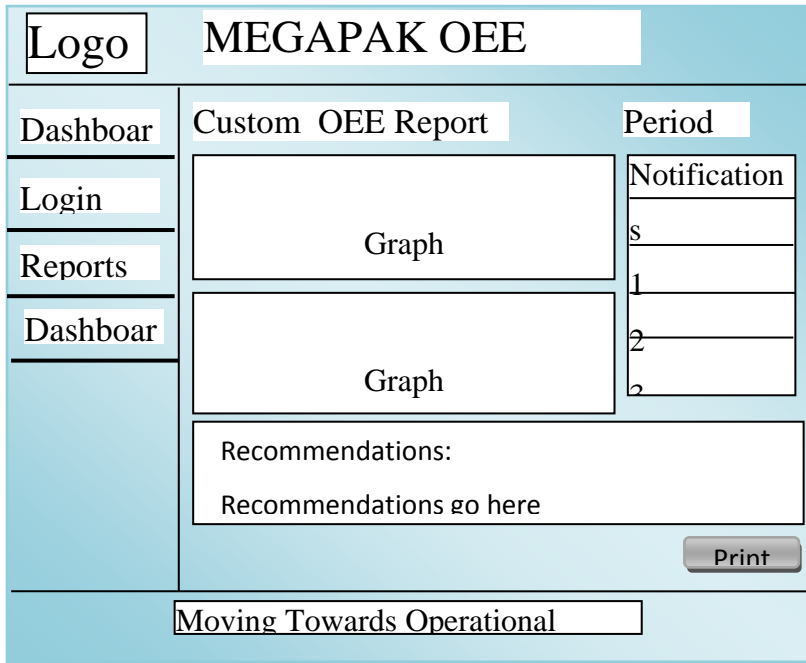
**Fig 4.22: Factory OEE dashboard**

Factory OEE allows management to prioritize resource allocation to factory with the highest OEE since it is here the six big losses to production will be reduced. Proper allocation of resources will result in greater profits as resources are given to the most efficient and cost effective factories.



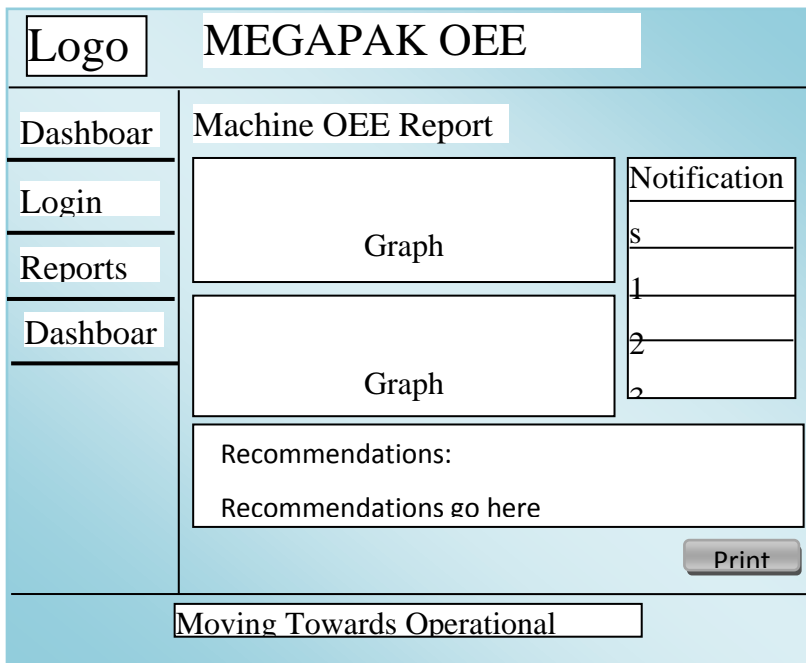
**Fig 4.23: Daily OEE report**

The report produced in fig 4.23 allows the user to print an A3 document that is displayed in the situation room on a daily basis. This document is one of the prerequisite activities to achieve operational excellence. Recommendations will also help the plant manager and management to make decisions on how to improve OEE.



**Fig 4.24: Custom OEE report**

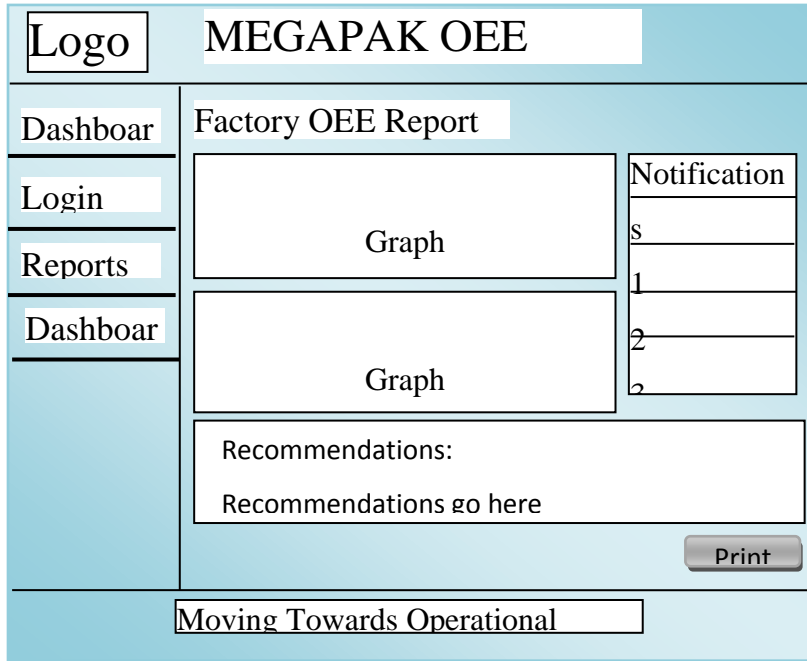
Fig 4.24 allows the users to produce custom report that can be printed as A3s. The recommendations given may give a time based analysis of the factors that lower OEE at particular periods of the year or month.



**Fig 4.25: Machine OEE report**

As machines become old they reach a stage where they are being constantly maintained which jeopardizes production and the organization's ability to respond to demand. The cycle

time will become much longer. Such analysis will be performed regarding each machine and be presented in fig 4.25. Management will be advised when the machine is no longer beneficial to have and needs to be disposed to make way for a new one.



**Fig 4.26: Factory OEE report**

The negative performance of a single factory may badly affect the overall performance of the whole organization. Such poorly performing factories will be flagged in fig 4.26 and recommendations on the course of appropriate action to be taken will be provided.

#### **4.8 PSEUDO CODE**

According to Agarwal et al (2010), pseudo code is a high level description in Structured English describing the operating principle of an algorithm or computer program. Pseudo code cannot be executed by a computer and is intended for human reading. It can be read by people with little or no programming knowledge.

##### **4.8.1 PSEUDO CODE FOR LOGIN FORM**

IF button login is clicked

    Connect to database

    Retrieve username, password and designation from database

    IF password and username is correct

        Check designation

```
IF designation is Plant manager
    Open plant manager page
IF designation is Production clerk
    Open operator page
ELSEIF password or username is empty
    print "Make sure you fill all details"
ELSEIF password or username is incorrect
    print "Incorrect details"
ELSE
    print "Validation failed try again"
```

#### **4.8.2 PSEUDO CODE FOR ADDING NEW PRODUCTION DETAILS**

```
IF session variables are not set
    return to login page
IF button add is clicked
    connect to database
    IF any field is empty
        print "Enter all required details"
    ELSEIF input is in an incorrect format
        print "Enter the correct format of data"
    ELSEIF input data is less than required
        print "Minimum characters to achieved"
    ELSE
        Add production to database
```

#### **4.8.3 PSEUDO CODE FOR UPDATING PRODUCTION DETAILS**

```
IF session variables are not set
    return to login page
IF button submit is clicked
    connect to database
    IF fields are empty
        print "Enter all required fields"
    ELSEIF insufficient amount of characters entered
        print "Insufficient amount of characters entered"
```



```
ELSEIF incorrect input entered
    print "Verify that input is in the correct format"
ELSEIF product code does not exist
    print "Invalid product code"
ELSEIF production status is false
    print "Updates cannot be added after production has ended"

ELSE
    Update production details
        print "Production successfully updated"
```

#### **4.8.4 PSEUDO CODE FOR ADDING DOWNTIME DETAILS**

```
IF session variables are not set
    return to login page
IF button submit is clicked
    connect to database
    IF fields are empty
        print "Enter all required fields"
    ELSEIF insufficient amount of characters entered
        print "Insufficient amount of characters entered"
    ELSEIF incorrect input entered
        print "Verify that input is in the correct format"
    ELSEIF product code does not exist
        print "Invalid product code"
    ELSEIF production status is false
        print "Downtime cannot be added after production has ended"

ELSE
    Update downtime details
        print "Downtime successfully added"
```

#### **4.8.5 PSEUDO CODE FOR CALCULATING DAILY OEE**

```
IF session variables are not set
    return to login page
```

Connect to database

Select production code which is either active or finished today

Calculate total downtime

Calculate total outputs and rejects

Calculate operating time and planned production

Calculate availability, performance and quality

IF output is equal zero

Quality equals zero

Calculate OEE

Display output

#### 4.9 SECURITY DESIGN

Security design is the collective process of safeguarding the organization's resources and infrastructure against unauthorized access and improper use (Deswarte et al, 2006). Richardson and Thies (2012) in support say that security design assists in promoting confidentiality and integrity to the organization's infrastructure, software and resources. Security design includes physical security, operational security and network security. Unauthorized access, improper use and system violation by hackers is prevented. In order to access critical pages on the system the user should have provided correct username and password. After successfully login, depending of the user's access level they will be redirected to different pages.

Logo

MEGAPAK OEE SYSTEM

LOGIN DETAILS

Access level

Access level

Access level

[Forgot Password](#)

Submit

Moving Towards Operational Excellence

### ***Fig 2.27: Security design***

Fig 2.27 shows a login form which will be used to prevent access of unauthorized users. The username, password and access level are stored in a MySQL database.

#### **4.9.1 PHYSICAL SECURITY**

Physical security is the protection of the organization's hardware and infrastructure by denying unauthorized access into the organisation or critical areas (Rittinghouse and Ransome, 2004). Physical security is put in place to protect the organisation workforce and resources from damage such as terrorist attacks, espionage and theft. To protect against theft Baker and Benny (2012) put forward physical measures such as fencing, locking, walls, surveillance, intrusion detection and alarms. They go on to suggest that in order to protect against natural disasters an organisation may make use of sprinklers, smoke detectors, heat detectors, fire suppression systems and fire proof doors among others. The need to physically protect the organization should not be over looked. It may become a huge threat if left unattended. Biometric access control can be used in conjunction with surveillance to prevent and monitor unauthorized and authorized access into a server room.

#### **4.9.2 NETWORK SECURITY**

Network security is a collection of measures put in place in order to prevent and mitigate unauthorized access, modification and misuse of network resources and infrastructure (Poole, 2007). The use of usernames and passwords may be useful to prevent unauthorized access. Users can be assigned an access level to regulate what functions they can and not perform in the system. Demilitarized zones (DMZ) and firewalls can also be used to prevent unauthorized access. Intrusion detection software (IDS) can be used to identify any intrusion into the system and deal with it before it causes any harm or damage to infrastructure, stored data and shared resources.

#### **4.9.3 OPERATIONAL SECURITY**

According to Herrmann (2007), operational security also referred to as OPSEC is the process of protecting an organization's unclassified and friendly data against to prevent adversaries from grouping it into meaning information. Adversaries are prevented from gathering critical information about the organisation from aggregating unclassified information. Measures to ensure OPSEC include authorization, access control, automation and dual control.

#### **4.10 CONCLUSION**

The flow of data within the proposed system was clearly illustrated through the use of a dataflow diagram and context diagram. Tables were used to show the various tables within the database. This is where the system data will be stored. Each table had all of its attributes as well as constrains. Interface design managed to show the different interfaces that users are going to interact with as they interact with the system. The interfaces had an easy side navigation bar to allow users to quickly and easily access their desired functions. The next chapter takes a look at the implementation of the system. It focuses on issues to do with system testing, changeover strategy and maintenance of the system. The chapter wraps up by giving a recommendation and evaluation of objectives. Into the next, the implementation phase will have a look at implementation and changeover strategies.

## **CHAPTER FIVE: IMPLEMENTATION PHASE**

### **5.1 INTRODUCTION**

The previous chapter looked at database design, physical design, interface design and architectural design of the proposed system. A dataflow and context diagram was used to show the flow of information within the proposed system. In this final chapter the main thrust is to ensuring that the system is correctly implemented to ensure that information arrives to the end user in the correct format and error free. In this chapter, different testing techniques and changeover strategies are analysed to ensure that the system is implemented in the most appropriate way to suite the present environment.

### **5.2 CODING**

Ruth (2006), defines coding as the process of using a programming language in order to write computer readable instructions. In addition (Roman, 1997) says coding is the process by which user requirements are translated into a computer readable format. Coding is useful in creating and linking together the different components and modules of the system. Coding starts after the generation of an algorithm of the system or a particular component. The next step becomes to write a pseudo code for the module. After there is a pseudo code the next stage is writing code snippets using a programming on compiler software. The compiler converts the code into assembly language and an assembler converts it into machine language. The programming language of choice in this project was PHP. PHP was appropriate since the system will be web based for convenient access for all users. For the database MySQL was used as the main database management system. Modules are the basic components of the system and where the system development had to start. These modules were then integrated to come up with the complete system. Bug testing and verification was done at module level in order to minimize integration problems. The appendices section includes the code of some of the modules created.

### **5.3 TESTING**

Software testing is the process of checking software to ensure that there are no discrepancies between input and output (Roth, 2006). It checks to see whether software is behaving in the expected manner. McEliece (2004) points out that software testing is a pivotal part in a system development lifecycle. The objective of testing is to ensure that the software is bug

free and meets user requirements. Simulated data was used for system testing. Both Black-box and White-box testing were applied in the testing of the system. As clearly pointed out by Roman (1997), white-box testing is the examining of the internal structures of a system and a programming aptitude is required. Roman (1997) also defines black-box testing as the examining of a system's functionality. It does not look into the internal structure and no programming aptitude is required.

### a) White-box testing

White-box testing involves the critical examination of the internal design of a system. A high level of programming expertise is required to perform this test. This test is performed at the system core. Input is selected and run through the whole system checking whether functions and modules perform correctly to produce the correct result.

### b) Black-box testing

According to Leveson (1995), black-box testing involves testing the functionality of the system in terms of the interaction of the interfaces. It involves providing input in the interface and checking whether the system produces the correct results. No programming knowledge is required to perform this test. The person performing the test should have a general understanding of how the system is expected to work and the results it is supposed to produce. If a form produces the appropriate results it is said to have passed the black-box test.

The image shows a web form titled "New downtime details". At the top, there is a red error message: "Downtime end date can not be less or equal to start date." with a close button (X). The form contains several input fields:

- Downtime code:** 10000019
- End date and time:** 2018-05-01 12:00
- Production code:** 10000008
- Comment:** Loose bolts
- Reason:** Engineering related
- Resolver:** Mashaya
- Start date and time:** 2018-05-08 12:00

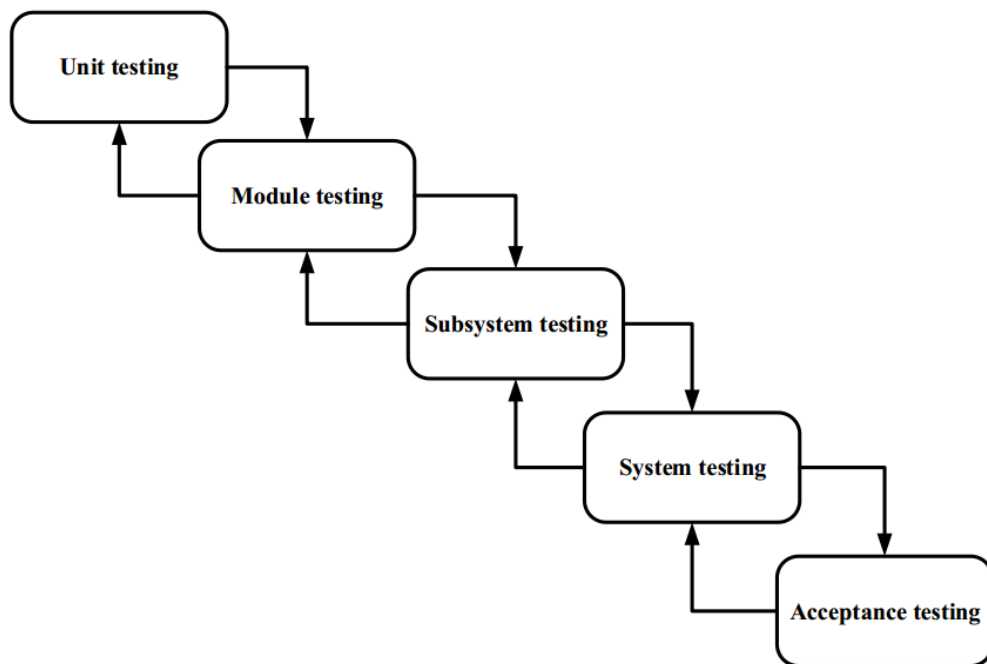
At the bottom right, there are two buttons: "Submit" and "All downtime".

**Fig 5.1: Black-box testing**

When adding new production details the start date cannot be greater than the end date as shown in fig 5. The system will produce an error if a user attempts such an operation.

### c) Defect testing

Defect testing involves debugging a program and identifying bugs and dealing with them (Leveson 1995). A program is said to have a defect if it produces an anomalous behaviour. Defect testing is a continuous and iterative process as defect are identified then corrected. The process is done again to ensure that the corrections do not result in other new bugs. This process is repeated until the program is free of defects.

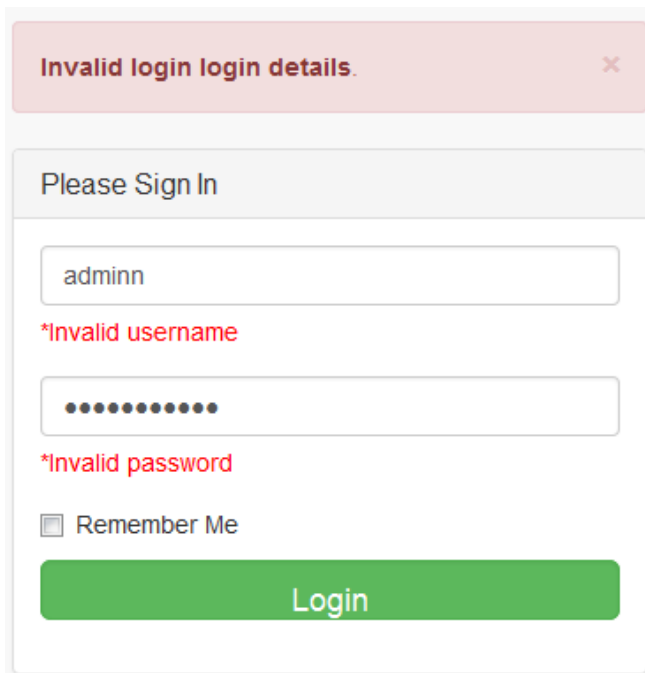


*Fig 5.2: Testing process*

#### 5.3.1 UNIT TESTING

Unit testing involves checking for errors in the smallest testable part of software (Ould and Unwing, 2002). Unit testing is very important since small units make up a modules which is in turn joined up to make the complete system thus there is need to make each unit to be error free and working properly. During unit testing units are tested individually and independently to ensure they are performing as expected.

The login page will be used to illustrate unit testing. The main objective of the login page is to allow authentic users access to other pages. The login page should deny access to unauthentic users after providing a false username and password. It should also provide an informative error message when the user has provided incorrect credentials.



*Fig 5.3: Login module unit testing*

### **5.3.2 MODULE TESTING**

Module testing is used to test related units within the system to ensure that they are functioning as desired. (Craig and Jaskiel 2002). Each individual module will be tested to ensure that it is functioning properly before being integrated into the complete system. The main object is to ensure that all related units of the system continue to function properly after they have been joined together. For example module testing in the downtime management would involve ensuring that downtime can be added, updated, trended and deleted.



Downtime end date can not be less or equal to start date. ×

## New downtime details

<b>Downtime code</b>	<input type="text" value="11027"/>	<b>End date and time</b>	<input type="text" value="2018-04-09 05:00"/>
<b>Production code</b>	<input type="text" value="10000009 - Preform 32G"/>	<b>Comment</b>	<input type="text" value="caused by electrical short"/>
<b>Reason</b>	<input type="text" value="Heatup downtime"/>	<b>Resolver</b>	<input type="text" value="Engineering"/>
<b>Start date and time</b>	<input type="text"/>	<input type="button" value="Submit"/>	<input type="button" value="Load"/>

**Fig 5.4: Downtime module testing**

### 5.3.2 SUBSYSTEM TESTING

Subsystem testing involves the checking of errors in an application after individual modules have been added together (Craig and Jaskiel, 2002). Its main object is to identify bugs that arise during and after the module integration process. Welling and Thomson (2003) elaborate more to say that subsystem testing focuses on identifying complications that arise in module interaction after they have been combined. They continue to say that it is important for continues integration strategy to take place, whereby modules are integrated one at a time in a serial manner identifying problems that arise. Errors that are identified are resolved and the combined components are checked again. Another module is added only if the current modules are error free. The above mentioned process is performed iteratively for all modules. This ensures that fewer errors arise at a given point in time and they are easy to resolve.

### 5.3.3 SYSTEM TESTING

According to Sommerville (2004), system testing is error checking performed on a complete system. It is a form of black-box testing since knowledge of programming is not required. It seeks to see if the systems functionality is representative of user requirements. It proves if the whole system is functioning in an error free manner and producing the appropriate results. All functions within the system were tested and the system passed the tests and corrections were made on those it failed and the system was tested again in an iterative manner.

### **5.3.4 ACCEPTANCE TESTING**

Acceptance testing is used to test whether the system meets user requirements (Sommerville, 2004). It checks if the system is performing as the users would like for it to perform in order to solve their problem or improve their situation. It is a platform for users to verify that the system meets the objectives that they specified. Users are basically given a chance to interact with the system and provide feedback regarding its functionality. At Mega Pak Zimbabwe the users agreed that the system meet their requirements as specified in the documentation. It was mention that the process of calculation the overall factory OEE was now much easier and that notifications kept them on high alert and made them to resolve problems more quickly.

### **5.3.5 VERIFICATION AND VALIDATION**

The simple difference between verification and validation is that verification is concerned with getting the system right and validation seeks to get the right system (Gonze, 2008). Validation checks if the system captures user requirements and verification checks if the final software meets set out specifications. Meeting user requirements meets that the system achieves its intended purpose.

#### **5.3.5.1 VERIFICATION**

According to Gonze (2008), verifications involves assessing an application to ensure that it is on the right track development wise. It seeks to check if development conforms to set specifications. It looks at the design specification and tries to confirm if they align to the software application being built. During a verification test it is necessary to execute the software. Proper verification entails that the program should accept correct input (strings and integers where appropriate) as well as produce expected results. Verification was carried out on all input forms in the Mega Pak OEE system. This was done to ensure correct results were obtained and errors would not arise from incorrect input. For example preventing typing strings where integers were required as this would produce an error in the future since the system would not be able to add string.

## New machine details

<b>Machine code</b> 10027	<b>Residual value</b> string
<b>Name</b> Inj404	<b>Useful life</b> string
<b>Model</b> 1.1	<b>Depreciation method</b> Straight line method
<b>Factory code</b> 1002-Large injection moulding	<b>Products produced</b> prm0003 - 22G Preform
<b>Purchase date</b> 2010-04-17	<b>Nameplate Capacity /hr</b> string
<b>Price</b> string	<b>Target OEE</b> string

Please enter a number.

Submit Load

**Fig 5.5: Machine addition verification**

In Fig 5.5 upon hitting the submit button the form validates if input is in the correct format. As shown in fig 5.5 the price of a machine cannot be a string format.

### 5.3.5.2 VALIDATION

Roman (1997), says that validation is the process of checking the software application during and after development to ascertain whether it satisfies user requirements. Its main focus is to ensure that the system meets user requirements. A validation test can only be passed if software meets user requirements.

### 5.3.5.3 TEST CASES

#### User

#### New user details

Employee ID\*  
214

Username\*  
pe  
A minimum of 4 characters required

Password\*  
.....  
A minimum of 8 characters required

Account status  
 Active  Disabled

Submit All users

**Fig 5.6: User add case**

The correct length of input is important to make data meaningful, for example a username cannot be a single letter. Fig 5.6 validates this by displaying an error when an incorrect input length is given.

#### Updating production

Productin update could not be added, there is no active. Add new shift details

#### Shift details

Shift code  
1000007

Shift  
Night Shift

Production code  
100000001

Shift start time  
2018-04-10 19:00

Shift supervisor  
201 - Quinton Abel Chabvuta

Shift end time  
2018-04-11 06:59

Breaks (minutes)  
10

Target output (units)  
10000

Target OEE (%)  
85

Submit Load

**Fig 5.7: Shift details case**

When updating production the system first validates that there is an active shift. If there is no active shift the system automatically redirects the production clerk to the shift addition page as shown in fig 5.7.

Update date cannot be less than production start date. ✕

### Update production details

<p><b>Update code</b>  <input type="text" value="1000000055"/></p> <p><b>Production code</b>  <input type="text" value="100000001 - Twisted cap"/></p> <p><b>Update time</b>  <input type="text" value="2018-04-01 12:00"/></p> <p><b>Total output</b>  <input type="text" value="1000"/></p>	<p><b>Rejects</b>  <input type="text" value="10"/></p> <p><b>Reason</b>  <input type="text" value="Startup rejects"/></p> <p><b>Comment</b>  <input type="text" value="comment"/></p> <p><b>Production status</b>  <input type="text" value="Continue"/></p>
---	--

**Fig 5.8: Update production case**

Production cannot be updated before the date and time it began. Fig 5.8 illustrates a scenario where a user tries to update production details at a date before production began.

## Downtime

Downtime updates can not be added after production has ended. ✕

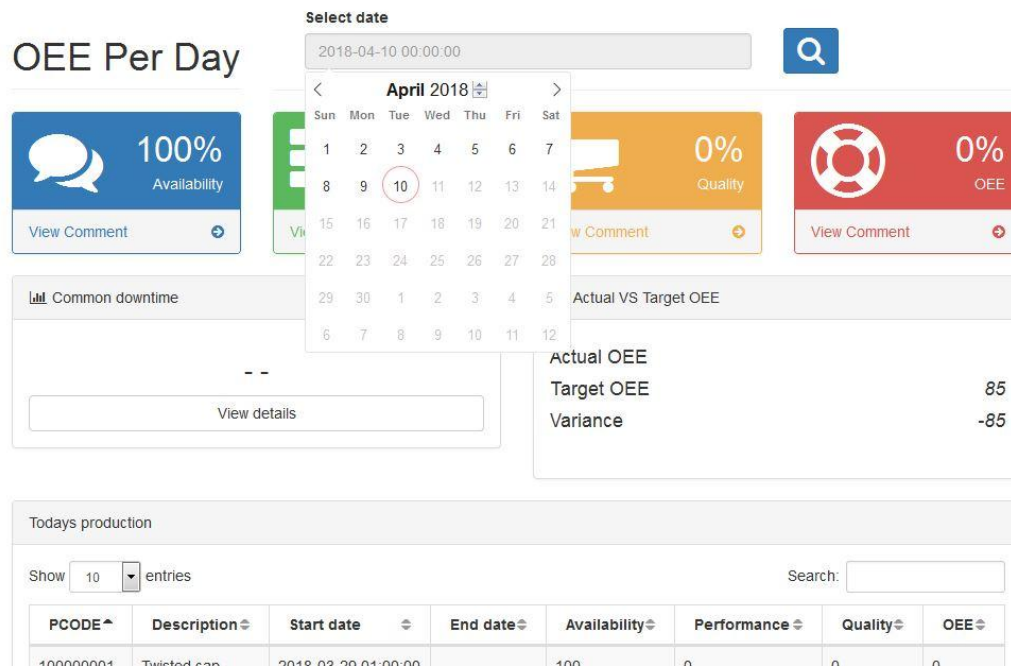
### New downtime details

<p><b>Downtime code</b>  <input type="text" value="11027"/></p> <p><b>Production code</b>  <input type="text" value="100000009 - Preform 32G"/></p> <p><b>Reason</b>  <input type="text" value="Engineering downtime"/></p> <p><b>Start date and time</b>  <input type="text" value="2018-04-10 03:00"/></p>	<p><b>End date and time</b>  <input type="text" value="2018-04-10 04:00"/></p> <p><b>Comment</b>  <input type="text" value="dsfsdf"/></p> <p><b>Resolver</b>  <input type="text" value="sdfsdf"/></p>
--	---

**Fig 5.9: Downtime case**

Downtime can only be added for an active production. Fig 5.9 show a scenario where the user tries to add downtime details after production had ended with an appropriate error message.

## OEE per day



**Fig 5.10 OEE per day case**

When searching the overall organisational OEE for a particular day the user cannot search for a day in the future. Fig 5.10 clearly shows this since future dates are disabled on the calendar.

## Login validation

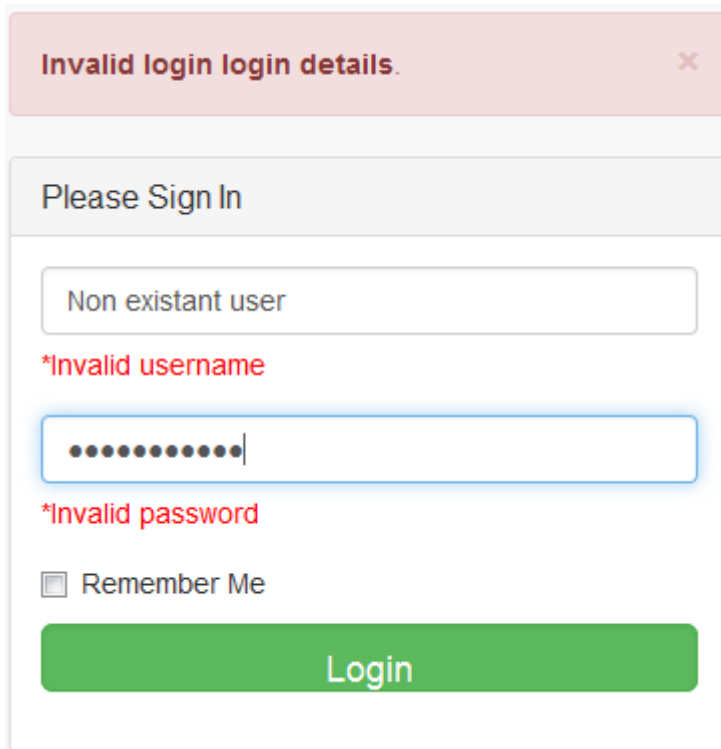
The screenshot shows a login form with an error message: "Invalid login login details." The form fields contain "Adm" for the username and "Password" for the password. Error messages below the fields state "\*Invalid username" and "\*A minimum of 8 characters required". There is a "Remember Me" checkbox and a green "Login" button.

**Fig 5.11: Login credentials validation**

A user's password should contain at least 8 alphanumeric characters including a special character as password. The system should generate a message when the user's password does not satisfy the above stated rule and deny them access.

#### 5.3.5.4 SECURITY TESTING

OEE data is sensitive company data and should be confidential and be view only by authorized users. Security testing checks whether the system is able to ensure data confidentiality by denying unauthorized users access to the system. This has been achieved through the use of passwords and sessions.

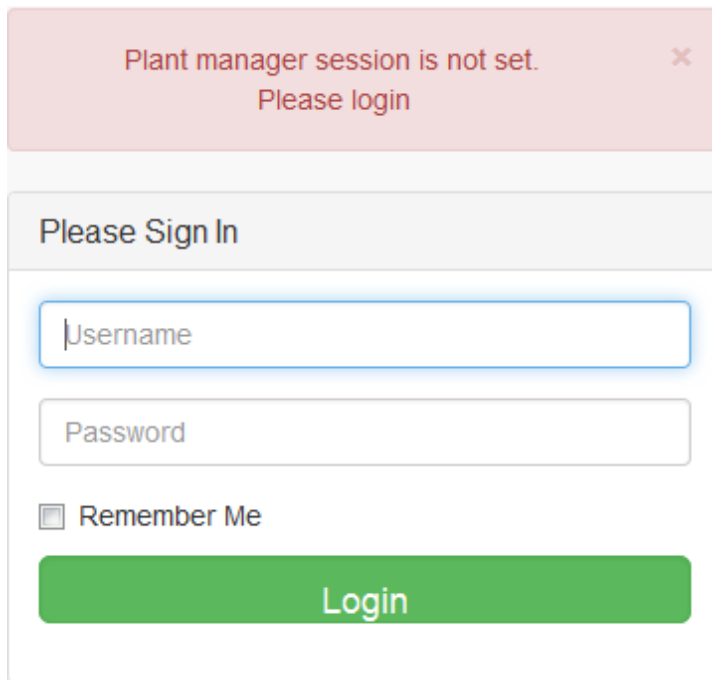


The image shows a web interface for a login form. At the top, there is a red error banner with the text "Invalid login login details." and a close button (X). Below this, the form is titled "Please Sign In". It contains two input fields: a username field with the text "Non existant user" and a password field with masked characters (dots). Below the username field, there is a red error message "\*Invalid username". Below the password field, there is a red error message "\*Invalid password". There is also a checkbox labeled "Remember Me" which is currently unchecked. At the bottom of the form is a green "Login" button.

**Fig 5.12: Login security testing**

Fig 5.12 illustrates a scenario where a user tried accessing the system using a non-existent user therefore being denied access.

## Designation case



The image shows a web interface for a login page. At the top, there is a red error message box with the text "Plant manager session is not set. Please login" and a close button (X). Below this is a white box with a grey header that says "Please Sign In". Inside this box, there are two input fields: "Username" and "Password". Below the password field is a checkbox labeled "Remember Me". At the bottom of the white box is a green button labeled "Login".

**Fig 5.13: Incorrect designation case**

After successful login sessions are set, if a user tries using the URL to access a page they will be returned to the login page as shown in fig 5.13.

### 5.3.6 USABILITY TESTING

Craig and Jaskiel (2002), define usability testing as how users find the interface of the system easy to navigate and use. It tests the level of difficulty new users face when trying to complete a particular task for the first time or performing a repetitive task. Users are more likely to enjoy using a system that they find easy to use than one that is complicated where general functions are difficult to locate. This type of test falls under the category of black-box testing. The interfaces of Mega Pak's OEE system are very easy to navigate with the navigation menu on the left side and notifications panel on the top.

### 5.3.7 PERFORMANCE TESTING

Performance testing checks the effectiveness and speed of the system (Desikan, 2006). It measures system throughput, response time, system stability and system scalability given different conditions. Stress test, load test, spikes test, scalability test, volume test and endurance test are just some examples of performance test



### 5.3.7.1 STRESS TEST

It measures the ability of the system to handle multiple requests at the same time. It seeks to ascertain the breaking point of the system. Some bugs may become prevalent as system requests tend to increase resulting in the system producing incorrect results. Common bugs due to increased requests include memory leaks and race conditions. Without this test the system can be thought to be perfect however hackers can exploit this weakness and undermine the systems security in order to gain unauthorized access. The behaviour observed during a stress test can give the programmer a better insight on how to handle high data loads

### 5.3.8 SYSTEM OBJECTIVES VERSUS SYSTEM SOLUTION

The following section looks at how the system went about achieving each objective set out in the chapter one of this project.

#### a) To measure individual machine effectiveness on a daily, weekly and monthly basis.

The main object of this project was to measure machine effectiveness and it was achieved allowing the plant manager and executive management to be able to view machine OEE reports. The plant manager does much of the initial ground work by adding machines, factories products and employees into the system. The production clerk is then responsible for adding downtime details, new production details and updates.

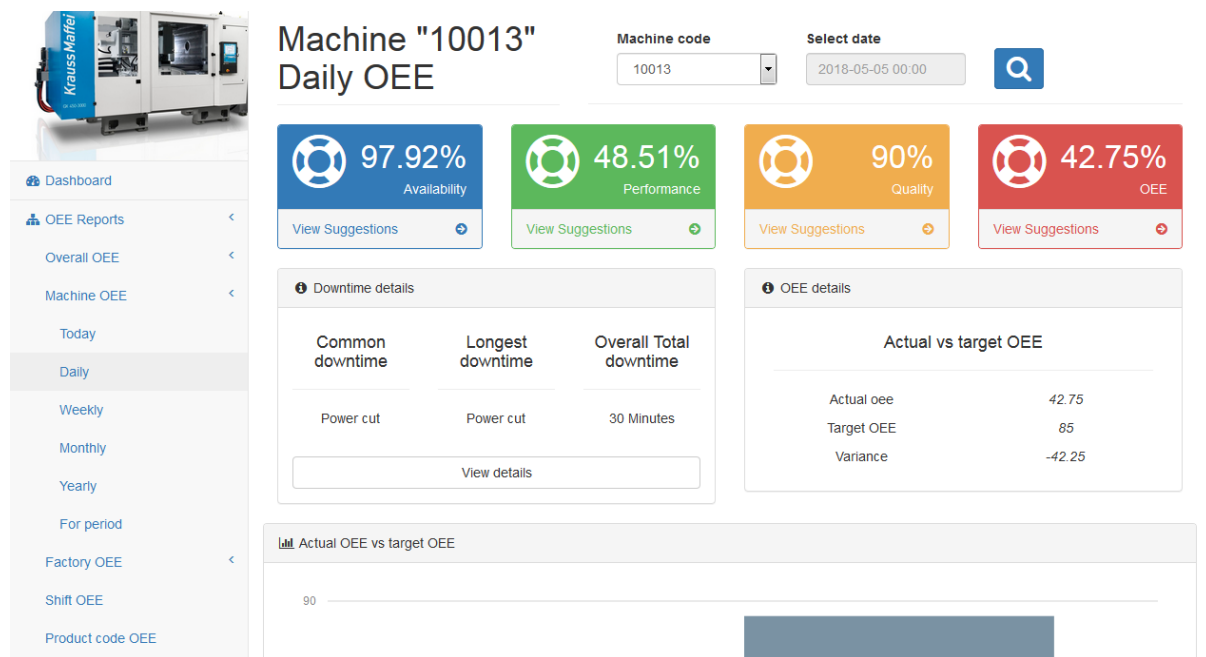
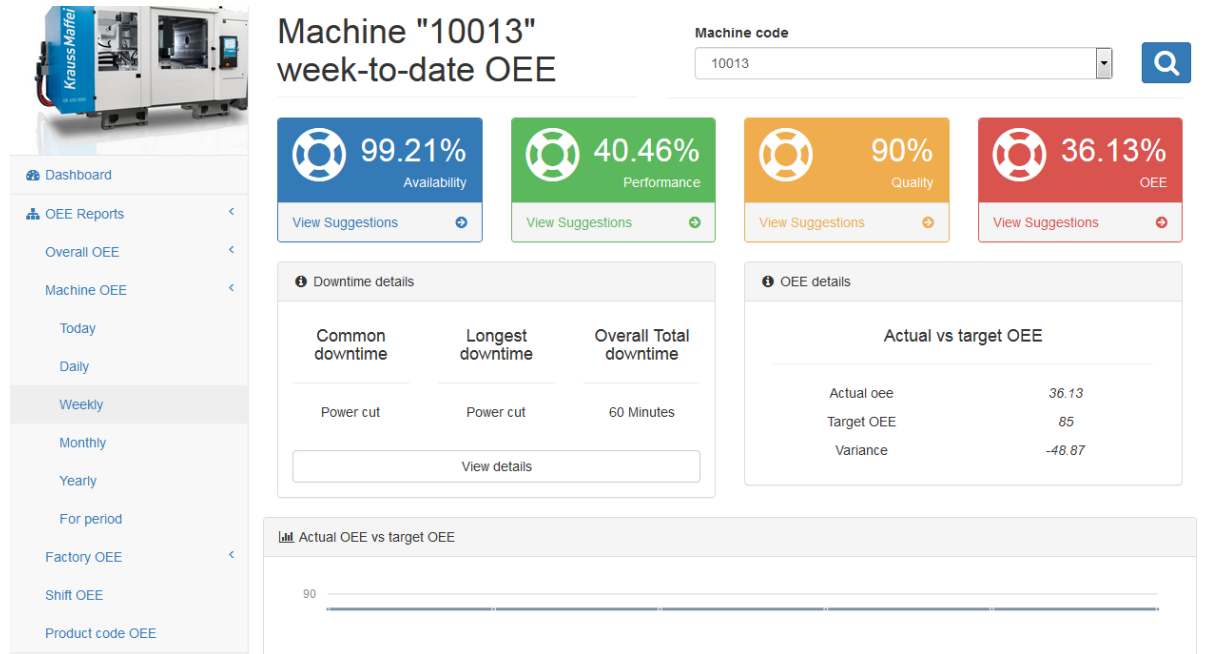


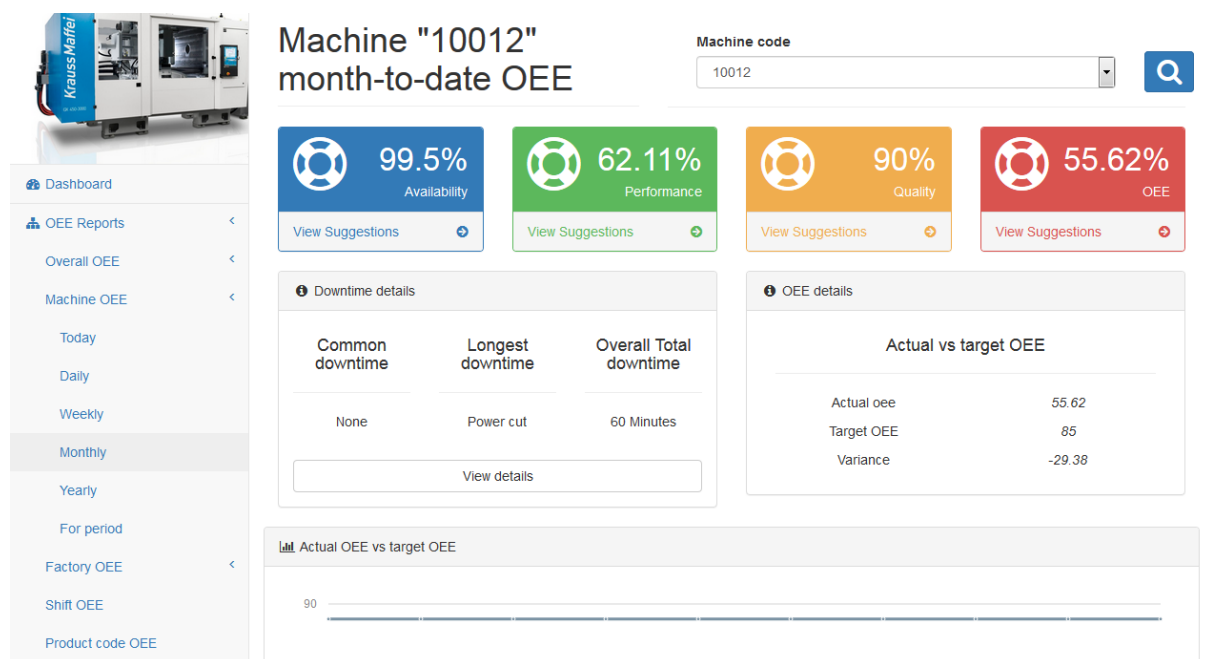
Fig 5.14: Daily machine OEE

After all prerequisite information about a machine's production has been added into the system the plant manager and executive management can now view a machines OEE report. Fig 5.14 shows machines OEE for a particular day



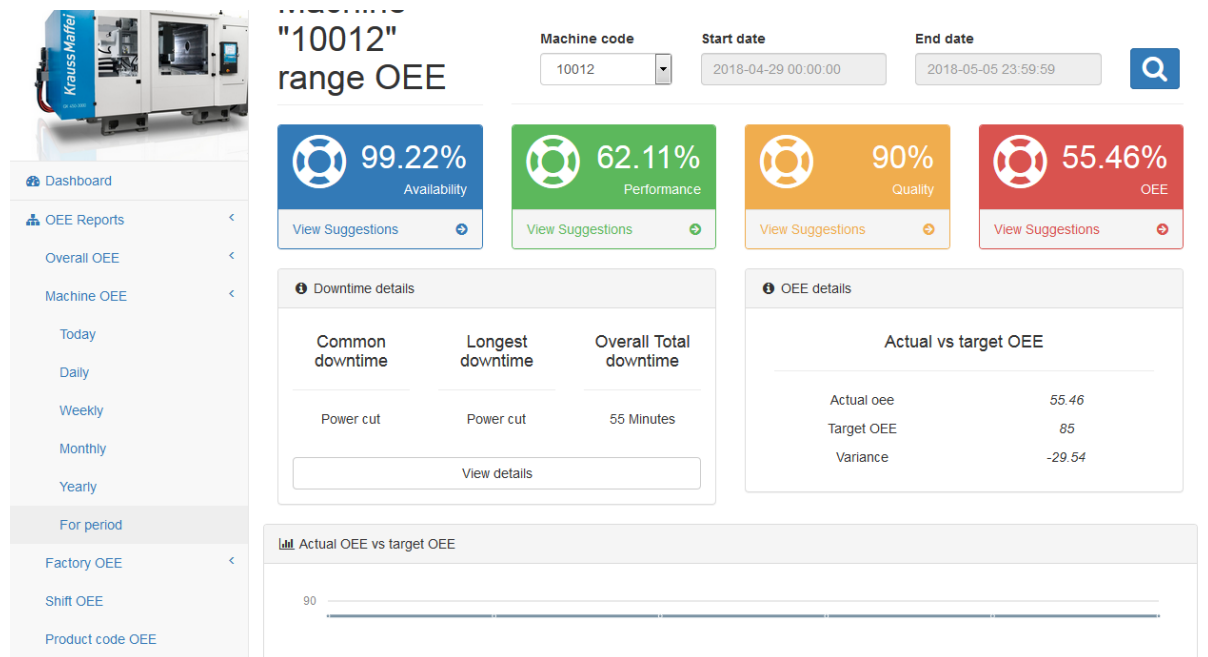
**Fig 5.15: Weekly machine OEE**

After selecting a desired machine code the user is now able to view the weekly OEE of the particular machine as shown in fig 5.15.



**Fig 5.16: Monthly machine OEE**

Fig 5.16 is similar to fig 5.15 in the sense that after selecting a desired machine code the user is now able to view the monthly OEE of the particular machine.

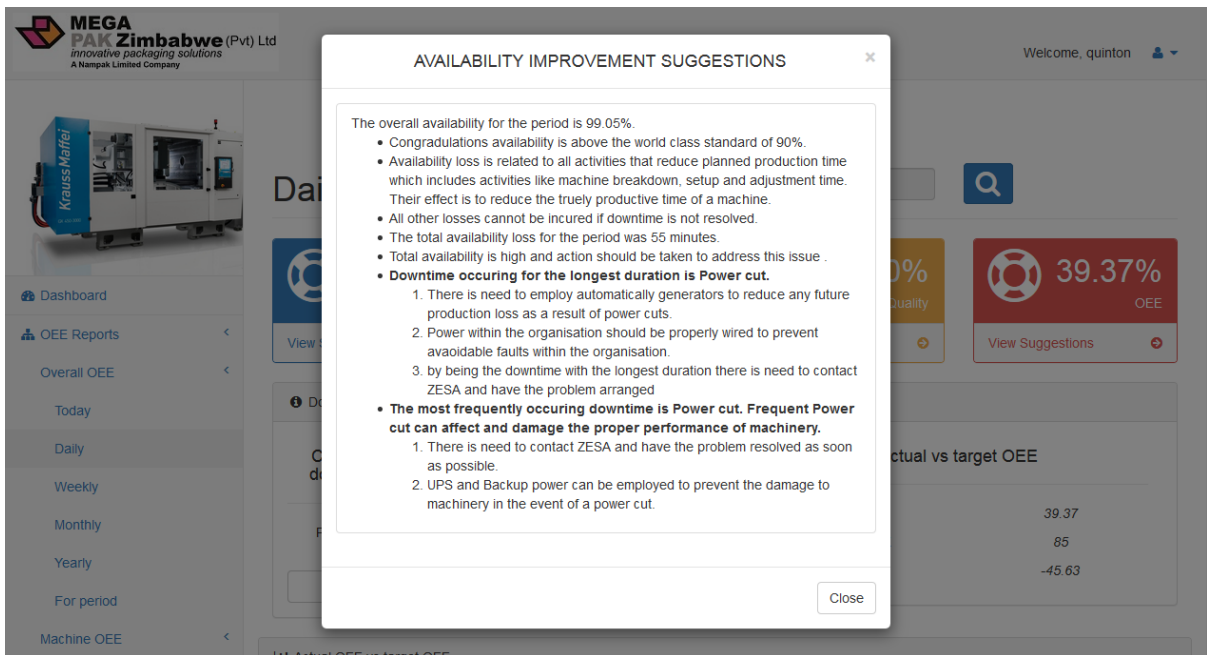


**Fig 5.17: Custom Machine OEE**

It is also possible for a user to view a machine's OEE for a particular period by selecting the period report. After selecting the desired period and machine the user is shown the OEE of the machine during that particular time.

**b) To suggest to the plant manager possible alternatives for reducing the losses to production and improve OEE**

The big losses to production affect each individual OEE variable which in turn affects a machine OEE. By clicking on view suggestion on each OEE variable the user is given a modal view with suggestions on how to improve that particular variable.

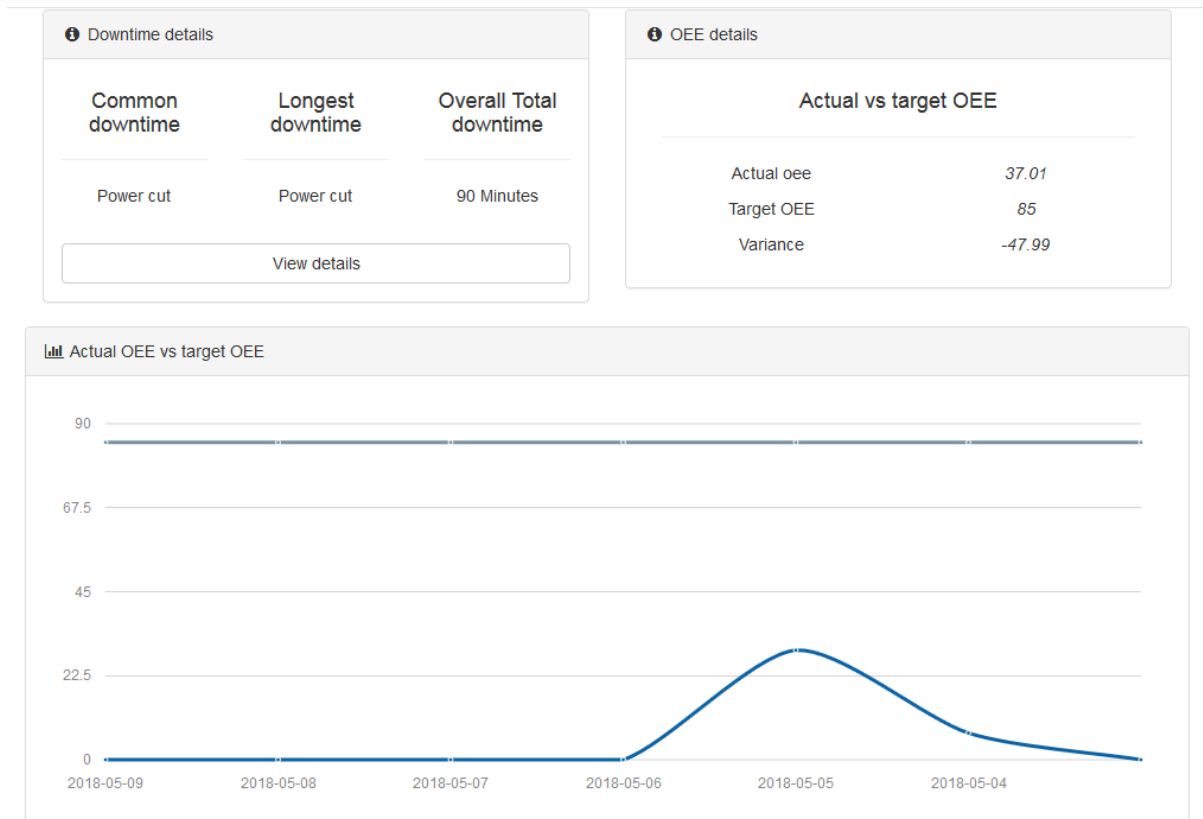


**Fig 5.18: Improvement suggestion**

The availability improvement suggestion in fig 5.18 suggests that power cuts are the most frequently occurring downtime and they also have the longest duration. Possible solutions have also been given

**c) To provide a comparison between actual OEE and Target OEE on a daily, weekly and monthly basis.**

When the plant manager adds a new machine or factory and when the production clerk adds new production they have the option to specify the target OEE for the machine or production code. Actual versus target OEE can be viewed per machine, per factory, per product code or for the organisation as a whole.

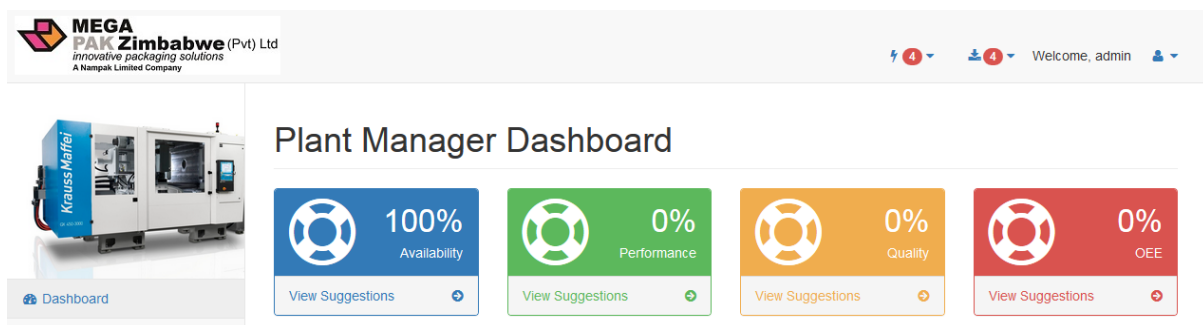


**Fig5.19:Actual versus target OEE**

Actual versus target OEE is shown in both a graphical format and a numeric values. During production this comparison helps shift know how much effort has to be put in order to achieve the desired target.

**d) To notify the plant manager through the dashboard when a machine OEE levels decrease below set targets**

In order for corrective action to be taken in time there is need to alert the responsible authorities at the right time. At the top right corner of the plant manager’s dashboard are notifications of all active machines and those below target.

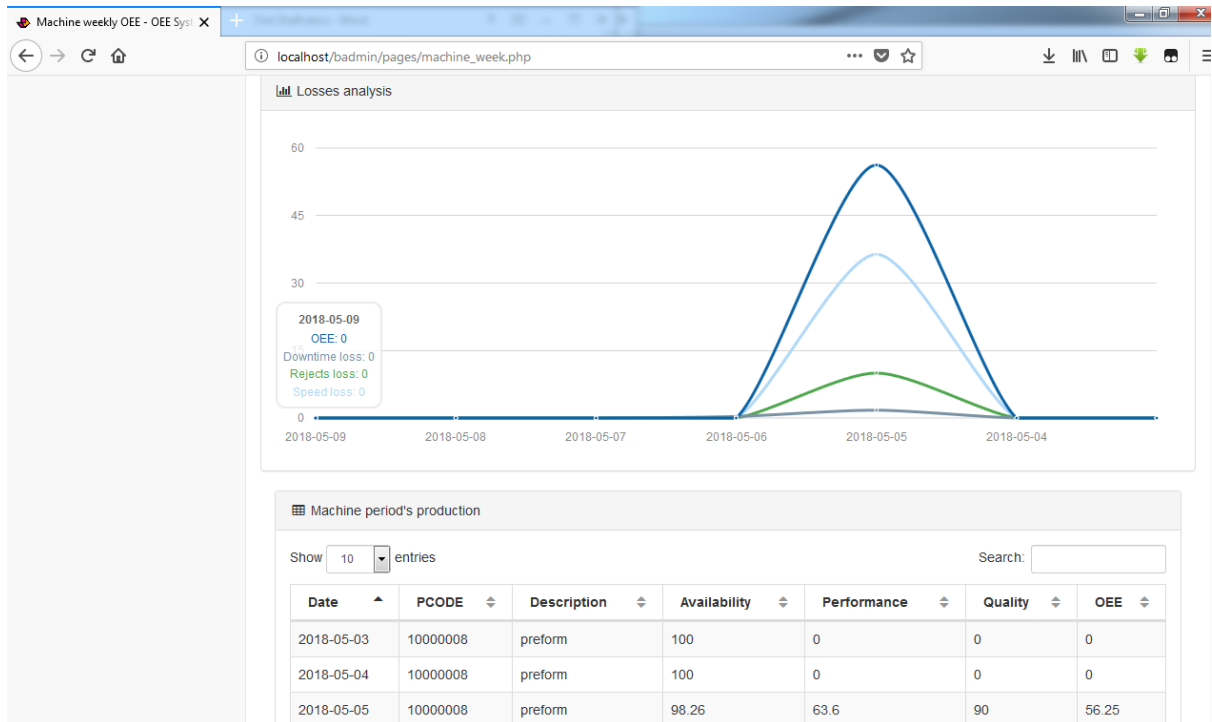


**Fig 5.20: Plant manager notification**

Top right notifications on the plant managers dashboard shows the number of machines that are below target as shown in fig 5.20.

**e) To measure and monitor the losses to production and evaluate their impact on a machine OEE**

Loss analysis shows the loss that has impacted the most on OEE. This helps to establish a trend about which loss is constantly affecting OEE and corrective action can be taken in time.

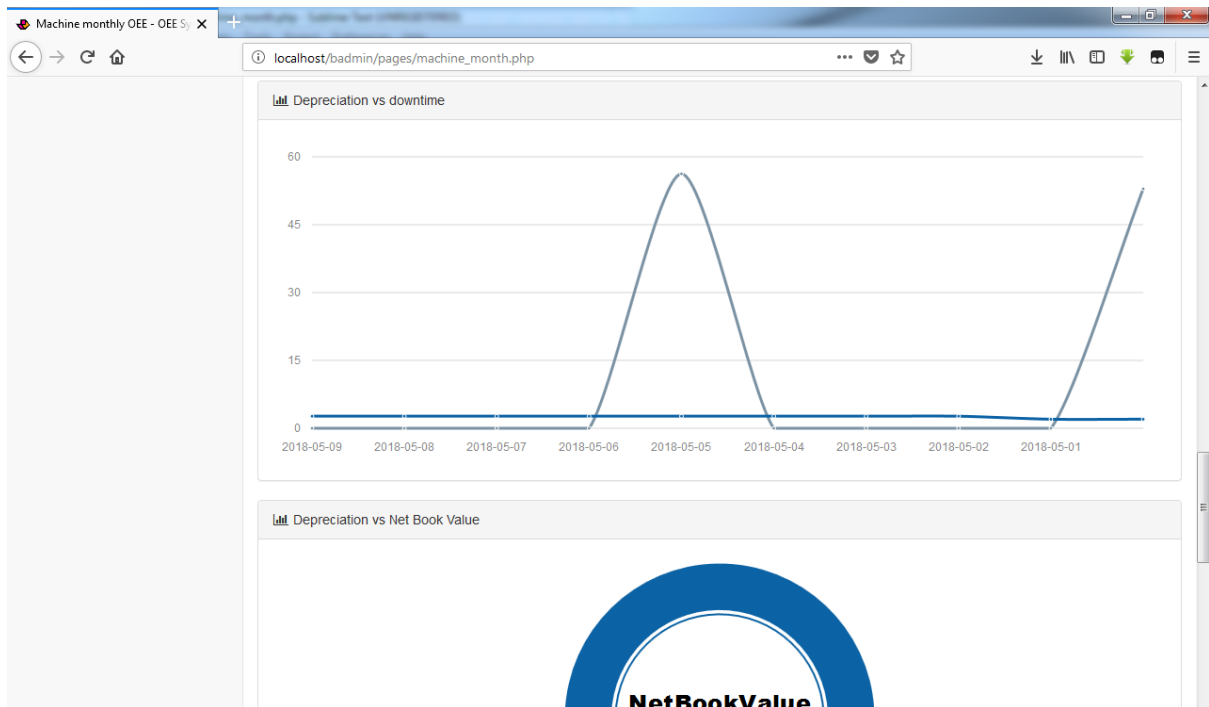


**Fig 5.21:Loss analysis**

In fig 5.21 speed loss has greatly affected OEE as its sharp increase had the effect of reducing OEE to below 60%.

**f) To evaluate the effects of machine depreciation on OEE on a monthly basis.**

Depreciation plays an important part in the overall performance of a machine. Machines with low depreciation tend to perform better than machines that have been working for many years with high levels of depreciation. Although constant maintenance may keep a machine in good shape it is important to constantly monitor the relationship between OEE and depreciation in order to take corrective action in time if need be.



**Fig 5.22: Depreciation versus OEE**

The relationship between OEE and depreciation is shown in fig 5.22 to determine whether there is a direct proportion between depreciation and OEE

## 5.4 INSTALLATION

A system that has passed acceptance testing is ready for deployment into the user environment. Roth (2006), elaborates that installation is the process of deploying a software application into the user environment. Setting up the application includes setting up the correct hardware and software on which the application is to run on. Mega Pak OEE system will be run from a centralized server giving access to other devices via the organizational intranet. Installation steps include:

- ❖ Installation of XAMPP on the server after installation of basic software such as PDF reader, web browser (Chrome), Microsoft Office 16
- ❖ Import the database onto the server
- ❖ Copy system files onto the server into Local disk C:\xampp\htdocs

### 5.4.1 USER TRAINING

User training is a very important aspect to successful application deployment. Its object is to teach users how to use the new application effectively. It involves teaching them general application navigation, data capture and most useful operations and functions.

Production clerks play a pivotal role in the system as they capture all machine runtime details. In order to effectively do this they should be able to be able to navigate all input pages without hassles. There is need to teach them how to input the correct data onto every page. Important to note is the format and measurements used in the system. For example it is important to note that all time measurements will be in minutes. The production clerks were trained in the production board for a whole day during the first session and for two hour for two consecutive days. A projector and laptops were used during the training session.

Management need to be able to navigate to different reports and also be able to print and save them. They need to be taught on how to apply filter on their reports to produce their customized reports. Their training session was carried out in the sales board room for three hours and they were given manuals to refer to later. A projector and tablets were used during the training session. The training session emphasised more on customising and interpretation of graph.

The plant manager has access to many area of the system, this means the plant manager should be able to also assist other users when they face minor difficulties while using the system. Among the many areas the plant manager's needs to know are how to add new machines, users, factories and know how to ensure that production clerks are inputting the correct data into the system. The plant manager should also be able to print and save reports required by management. The plant manager was involved in the training sessions for all the other users. As a critical person in the system, the plant manager has to be able to navigate the whole system and provide assistance to other users where necessary. A separate training schedule was conducted with the plant manager on the last day of training where all components of the system were analysed.

Detailed information regarding how to navigate all pages is included in the appendices section

#### **5.4.2 DATA MIGRATION**

Burns (2008) defines data migration as the movement of data from one system to another, in this case from the old system into the new system. During data migration the data does not change format but the storage medium may change. Data was moved manually into the new



system. To curb duplication of data, validation will be enforced during the inputting of every data element into the system. Verification and validation ensure that data in the correct format is entered into the system. The security risk of data being hacked or sniffed during migration is very low since migration will take place on an offline machine.

### **5.4.3 SYSTEM CHANGEOVER**

According to Burns (2008), system changeover is the process of switching from one system to another. Failure by IT managers to address this aspect may lead to colossal problems and failure. Different ways of changing from one system to another exist each with its own advantages and drawbacks. System changeover is broad and results in many changes in hardware, software, data and user training. Among the different changeover strategies are parallel changeover, phased changeover, direct changeover and pilot changeover. Selection of a single strategy is influenced by environmental factors and as such is organizational independent. A direct changeover strategy was employed for this project.

#### **5.4.3.1 DIRECT CHANGEOVER**

A direct approach simply replaces the old system with the new system (Shelly and Rosenblatt, 2008). The old system is completely discarded to make way for the new system whose use begins immediately. Proper user training and detailed user manuals greatly aid the success of this strategy as users can instantly begin using the new system without any challenges.

##### **a) Reason for using direct changeover**

- ❖ Duplication of data and resources is reduced
- ❖ The cost of changeover is reduced
- ❖ Results in no loss in data
- ❖ The system is not critical to production hence some downtime it tolerable

#### **5.4.3.2 PILOT CHANGEOVER**

Pilot changeover entails selecting a sample from the system users to test the new system (Desikan, 2006). During this period system performance is analysed and if any problems arise they are dealt with as they arise until the system is perfect. On the good recommendations from the sample group is the system then implemented in the whole organization. Pilot changeover allows for further evaluation of a system before it is used.

#### **a) Inappropriateness of the strategy**

- ❖ The staff compliment is limited and no extra personnel can be allocated for a pilot system.
- ❖ Duplication of resources and data is uneconomic and may result in confusion
- ❖ Employment of additional staff to replace those allocated to a pilot project can greatly increase the sage bill.
- ❖ Staff that do not engage the pilot system may feel segregated and ultimately resist the new system.
- ❖ A pilot system environment may not reflect the actual system environment.

#### **5.4.3.3 PHASED CHANGEOVER**

This changeover strategy involves implementing the system module by module (Desikan, 2006). The implementation of the next module is dependent on the success previous module. During the period when one module is implemented the other system function will be handled by the old system. When challenges with the current module are identified they are first solved before implementing other modules.

#### **a) Inappropriateness of the strategy**

- Modules in the system are dependent on each other hence the system cannot be implemented separately.
- Since module implementation does not take advantage of economies of scale
- User training will need to be carried out for each module which disturbs the workflow.
- Duplication of effort may occur as users interface with two different systems which may require the same set of information

#### **5.4.3.5 RECOMMENDED CHANGEOVER STRATEGY**

After considering of each of the changeover strategies, direct changeover was found to be the most appropriate strategy for the organization. The currently prevailing economic situation makes it difficult for the organization to invest a lot of money at this point in time. Besides being cost effective, direct changeover is convenient for end users since they need to learn the system once. After learning how to use the system users can then increase their aptitude as they use the system.

## **5.5 MAINTENANCE**

According to Grubb and Takang (2003) maintenance is process of continuously making changes onto the system in order to increase functionality, validity and efficiency. Maintenance is necessary to keep the system updated and prevent it from being outdated. It is carried out in order to make the system adaptive to changes in environment. Maintenance ensures the survival of the new system. Other reasons for software maintenance include:

- Detection of new errors.
- Incorporate user needs that arise later.
- Incorporate changes in the sequence of business process.
- Solve and adapt to changes in software, hardware and technical issues.
- Adapt to new government regulations.
- 

### **5.5.1 CORRECTIVE MAINTENANCE**

Grubb and Takang (2003), point out that corrective maintenance as the name suggests is a reactive form of maintenance. It seeks to deal with bugs and problems after they have arisen. Corrections need to be handled with urgency lest the users lose confidence in the system and the reliability of its performance. No schedule can be developed for problems that arise during the systems use, the developer is committed to swiftly respond to these errors and provide a timely solution

#### **5.5.1.2 ADAPTIVE MAINTENANCE**

The process of continuously refining the system to adapt to environmental changes is referred to as adaptive maintenance (Grubb and Takang, 2003). Its main aim is to keep the system relevant to the users regardless of changes in the environment. Changes in the environment may include new production procedures, different shift system and changes to the organizations infrastructure. Left unattended the system may quickly become obsolete and of no further use to the organization. Adaptive maintenance was scheduled to be carried out whenever there is a change that affects the systems environment, further delays may result in users developing a negative attitude towards the system hence the need to act swiftly.

#### **5.5.1.3 PERFECTIVE MAINTENANCE**

Denis (2012) refers to perfective maintenance as the process of increasing the system performance, reliability and adding new features. It seeks to increase the system's perceived

usefulness and ease to use. It will be carried out biannually together with perfective maintenance during stock take.

#### **5.5.1.4 PREVENTATIVE MAINTENANCE**

Preventative maintenance seeks to identify and solve problems before they occur (Denis, 2012). A schedule is usually created for preventative maintenance with dates and time periods in which it will occur. It seeks to assure that the system maintains its performance level. Preventative maintenance will be carried out biannually during half year and year end stock take when there is no production being done.

#### **5.6 RECOMMENDATIONS FOR FUTURE DEVELOPMENT**

Inappropriate hardware, lack of funding, inadequate user training, poor planning and maintenance and incorrect system conversion strategies may adversely affect the implementation of the system.

Being web based system Mega Pak's OEE system needs to be hosted online. This will allow production clerks in different factories to communicate and exchange information more easily. The organization can also cater for factories in different geographic locations to upload their data into the system in real-time.

In the future there is need to integrate the system with dashboards in the production area. The electronic boards will show the active machines in the factory, their output, and target OEE level versus their current OEE level.

Given enough resources in the future the system should be able to send email notifications directly into the inbox of the plant manager alerting when a machines OEE has decreased below set target. Given that the plant manager moves from factory to factory it may be necessary to send SMS notifications directly into the plant manager's mobile phone to allow the plant manager to be mobile and flexible.

In the future the system should be integrated with the machines in order to be able to take data directly from the machine. This will be achieved through the use of sensors on the

machines directly collecting updates regarding machine output, speed and downtime details. Less human involvement reduces chances to errors and produces accurate data.

There is need to update the system in the future to have a password policy in line with Nampak standards whereby the user's password expires after every 42 days and needs to be changed. This will improve the overall security and integrity of the system. OEE information in the wrong hands can be used to do things that can have a detrimental effect to the organisation.

### **Other recommendation**

For security reasons there is need to update the database server to the latest version. This helps guard against vulnerabilities within the database. Content in the database should also be constantly updated to reduce redundancy. New machines should be added whenever they are bought and old machines removed when they become obsolete.

Hardware and the organizations infrastructure need to be properly configured to allow the system to work without challenges. Managed switches and VLANs need to be configured to allow communication carried out by the system.

## **5.7 CONCLUSION**

This chapter is the last chapter and it focused on how the proposed system was going to be implemented. Testing which is an important part for the correct implementation of the system was considered in the early parts of the chapter. Validation and verification went on to look at the appropriateness of the system in meeting and exceeding user expectations. An easy to navigate interface was used to help users quickly access core function that they perform repeatedly. Marking the end of this chapter was the changeover strategy which helped in accessing the most appropriate way to implement the system. Implementation is an ongoing process hence the need to continuously evaluate whether the system is meeting user requirements.

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## APPENDICES

### APPENDIX A: USER MANUAL

The user manual was created to help users familiarise with the system and know how to navigate all pages within the system. It can also assist in future reference and help in maintaining and updating the system.

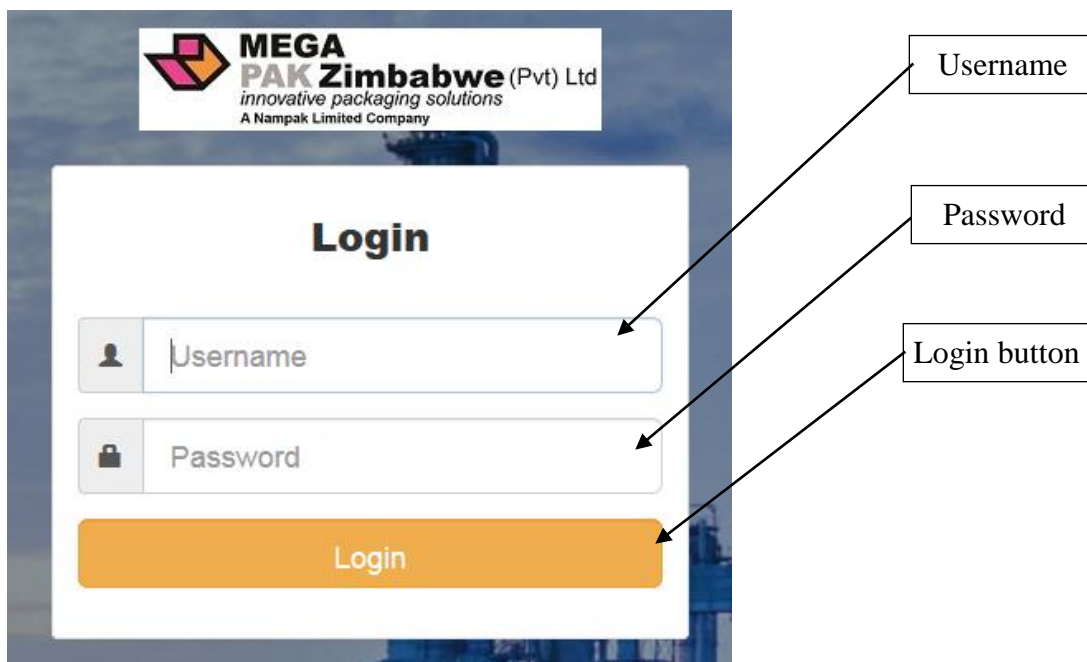
#### About the system

The Overall Equipment Effectiveness system is a web based system that runs on an apache server and can be accessed from multiple computers over the local area network. Any machine on the organisations LAN is able to access the system but only users can authentic users can use it. The system was developed using PHP, html, java script and CSS and MySQL server was used to host the database. After successfully accessing the system the first page to be displayed is the home page.

The home page is basic and requires for the user to proceed to the login page in order to be able to access more features.

#### Login

Users need to provide their login credentials on the login page in order to access their dashboards and perform their desired task. After entering the username and password the users should press the login button.



*Fig A1: Login form*

## Homepage

The homepage is the first page that users will meet as soon as they start to run the system. It welcomes the users to the system and provides a link to the login page.

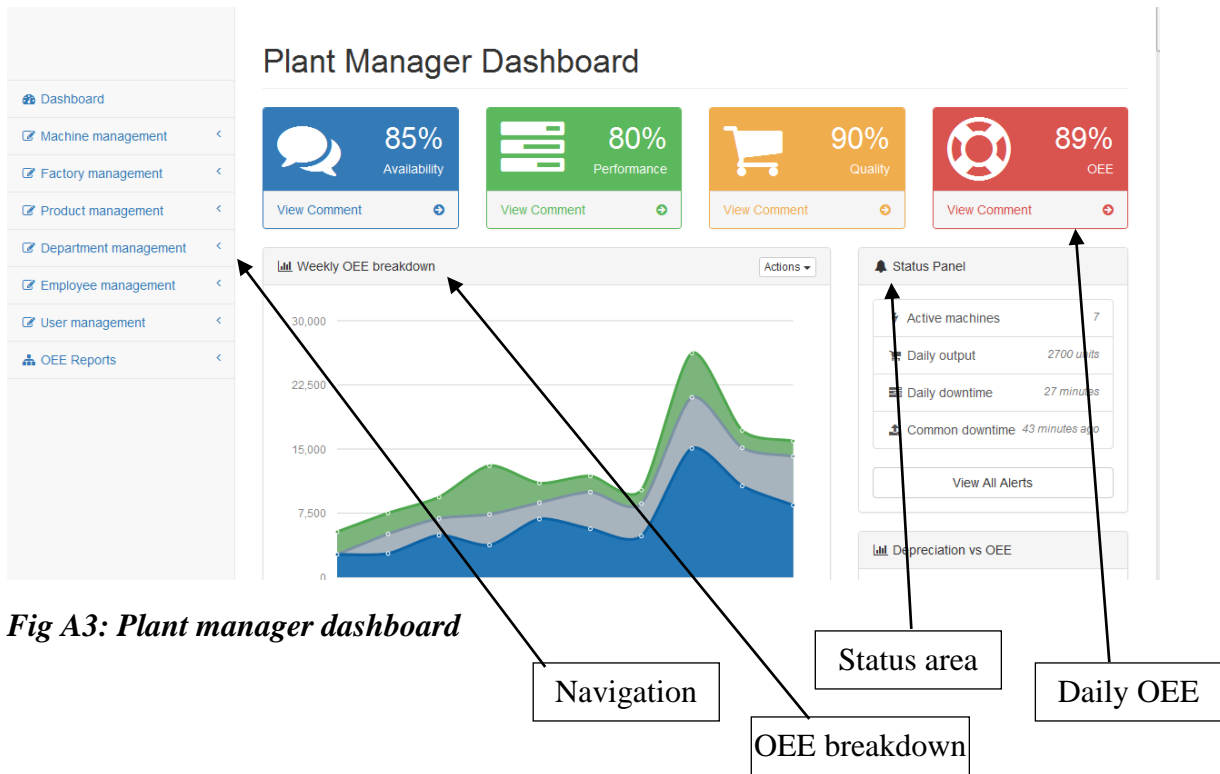


**Fig A2: Homepage**

Proceed

## Plant manager dashboard

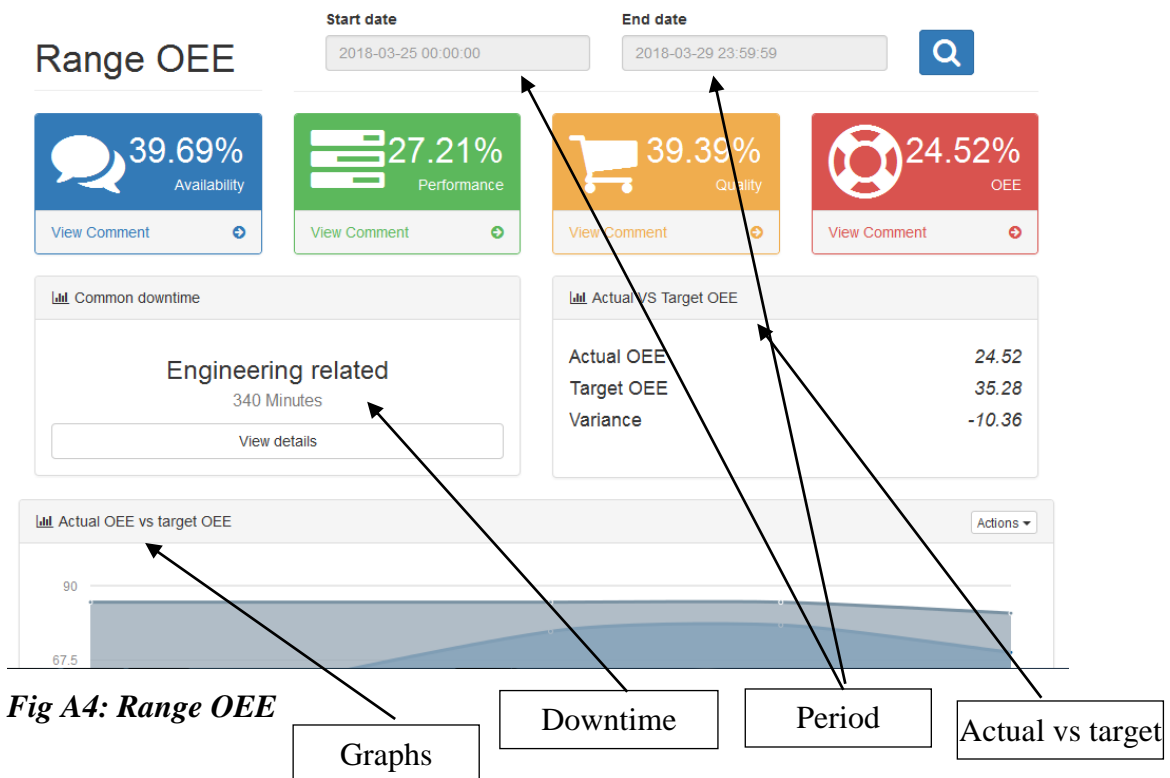
The plant manager dashboard gives the plant manager access to many pages. It also displays the overall daily OEE. From this page the plant manager can then proceed to other pages and view OEE reports, add new machines, new factories and manage employees.



**Fig A3: Plant manager dashboard**

**OEE report**

The main role of the plant manager will be to track and monitor OEE trends. This implies that the plant manager will spend more time viewing and analysing OEE reports. OEE reports are highly customizable. Overall OEE can be measured per day, week, month or year. Likewise machine and factory OEE can also be viewed for the ranges named above. The plant manager can also view OEE per shift or for the day. Fig A3 shows the OEE for a custom date.



**Fig A4: Range OEE**

## Add product

After the initial setup of the system the plant manager will be responsible for adding new products into the system. Important details to include when adding a new products is its product code, name measurements and colour.

### New product details

The form contains the following fields:

- Product code
- Width
- Product name
- Weight
- Height
- Color

At the bottom right, there is a blue button labeled "Submit load".

Callouts in the image point to the "Product details" label (covering the input fields) and the "Submit" label (covering the "Submit load" button).

Fig A5: Add products

## Machine custom OEE report

The dashboard displays the following information:

- Header:** MEGA PAK Zimbabwe (Pvt) Ltd, innovative packaging solutions, A Nampak Limited Company. Welcome, admin.
- Machine:** Krauss Maffei "10012" range OEE
- Filters:** Machine code: 10012, Start date: 2018-04-29 00:00:00, End date: 2018-05-05 23:59:59.
- Key Metrics:**
  - Availability: 99.22%
  - Performance: 62.11%
  - Quality: 90%
  - OEE: 55.46%
- Navigation area:** Dashboard, OEE Reports (Overall OEE, Machine OEE), Today, Daily, Weekly, Monthly, Yearly, For period.
- Downtime details:**

Common downtime	Longest downtime	Overall Total downtime
Power cut	Power cut	55 Minutes
- OEE details:**

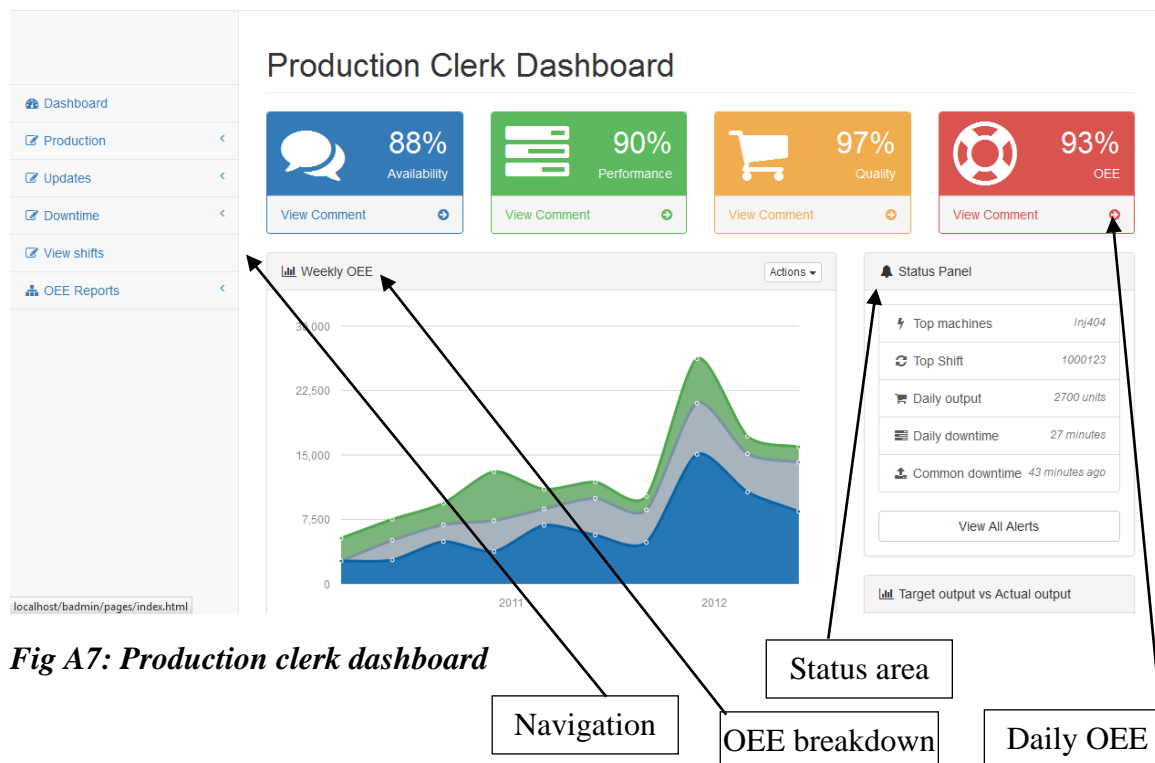
Actual vs target OEE	
Actual oee	55.46
Target OEE	85
Variance	-29.54

Callouts in the image point to the "Navigation area", "Downtime details", "Custom period" (pointing to the date filters), "OEE suggestions" (pointing to the "View Suggestions" buttons), and "Logout" (pointing to the user profile icon).

Fig A6: Machine custom report

## Production clerk dashboard

The production clerks are responsible for inputting all machine runtime details. On their dashboard they are able to access pages that allow them to add new production details and update active production details. They can also view OEE for machine on a date of their choice.



**Fig A7: Production clerk dashboard**

## Add production

The main task of production clerks is to add new production details into the system. The production code is automatically generated by the system.

## New production details

The form for adding new production details includes the following fields and controls:

- Production code:** Input field containing '100000011'.
- Start date and time:** Empty input field.
- Description:** Empty text area.
- Machine:** Dropdown menu.
- Target output (units):** Input field with a spinner.
- Target OEE (%):** Input field containing '85' with a spinner.
- Submit:** A blue button labeled 'Submit' with a 'Load' link next to it.

Annotations with arrows point to 'Production details' (the form fields) and 'Submit' (the button).

**Fig A8: Add production**

## Add production updates

After a new production has been added there is need to continuously update output, rejects and downtime details. On the updates page the clerk starts by selecting a production code which they wish to update then add their updates to it.

### Update production details

The form contains the following fields:

- Update code:** Text input field containing '10000000055'.
- Production code:** Dropdown menu.
- Update time:** Text input field.
- Total output:** Text input field with a small arrow icon on the right.
- Rejects:** Dropdown menu.
- Reason:** Dropdown menu.
- Comment:** Text area with a small icon on the right.
- Production status:** Dropdown menu with 'Continue' selected.
- Submit:** Blue button.

Annotations below the form:

- A box labeled 'Update details' has an arrow pointing to the 'Total output' field.
- A box labeled 'Submit' has an arrow pointing to the 'Submit' button.

*Fig A9: Update production*



**APPENDIX B: INTERVIEW**

Interview questions for workers and employees at Mega Pak Zimbabwe

**Date:** June 2017      **Time:** .....

- 1. May you provide your organization's history

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- 2. How does the current OEE calculation system work

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- 3. How is the system achieving the objectives of the organization

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- 4. Are any challenges being faces with the current system? If any please elaborate.

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5. If a new system is to be developed which key areas should be addressed

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6. What expectation would you put upon a new computerized system

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## APPENDIX C: QUESTIONNAIRE CHECKLIST

Questionnaire to employees and management at Mega Pak Zimbabwe

**May you kindly respond to the following questions by ticking where appropriate. Please provide an honest answer.**

1. Which type of system is currently being used at your organization?

Manual       Semi-computerised       Computerised

2. How frequent are disruptions to the current system

Frequent       Occasionally       None

3. What rating would you give the current system

Excellent       Good       Fair       Bad

4. If any areas require improvement kindly specify them.

Response time       Data storage       Processing speed

Physical security       Data security       Processing speed

5. Can the system manage to meet deadlines

Yes       No

If not please specify the reason

.....  
.....  
.....  
.....

6. How often do you perform backup the system

Daily  Weekly  Monthly  Yearly  Never

If backup is performed where is it store and how reliable is it?

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7. Does the organisation have ways to restrict unauthorized data access? If yes, please specify.

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8. How fast id the search for the OEE of a particular machine or date and do the users encounter any problem during the searching?

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.....  
.....

**Date .....**

**Time.....**

**Employee designation.....**

**Signature .....**



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## APPENDIX E: SNIPPET OF CODE

### Login page

```
<?php
session_start();
$serr = "";
$message = "";
$serr_username = "";
$serr_password = "";
include_once 'conn.php';
$sql = "SELECT * FROM login";

$username = $password = "";
if (!isset($_POST['btnLogin']) && isset($_SESSION['pmError'])) {
    $serr .= $_SESSION['pmError'];
}elseif (!isset($_POST['btnLogin']) && isset($_SESSION['opError'])) {
    $serr .= $_SESSION['opError'];
}else{

}

if ($_SERVER["REQUEST_METHOD"] == "POST"){
    if(isset($_POST['btnLogin'])){

        if(empty($_POST["username"])){
            $serr_username = "Username required";
        } elseif (strlen($_POST["username"])<4){
            $serr_username = "A minimum of 4 characters required";
        }else {
            $username = test_input($_POST["username"]);
        }

        if(empty($_POST["password"])){
```

```

    $err_password = "Password required";
} elseif(strlen($_POST['password'])<8){
    $err_password = "A minimum of 8 characters required";
} else {
    $password = test_input($_POST["password"]);
}

if (!empty($_POST['username']) && !empty($_POST['password'])){

    //$password = md5($password);
    $sql = "SELECT login.username, login.password, employees.full_name,
employees.designation FROM login, employees WHERE login.eid = employees.eid AND
username='$username' AND password='$password' LIMIT 1 ";
    if($data = mysql_query($sql)){
        while ($row = mysql_fetch_assoc($data)) {
            $_SESSION['auth'] = true;
            $_SESSION['user'] = "$row[username]";
            if (" $row[designation]" == "Production clerk") {
                header('Location: opDash.php');
            } elseif (" $row[designation]" == "Plant manager") {
                header('Location: pmDash.php');
            } else{
                $err .= "Invalid designation. Only production clerks and plant manager can
access the system.";
            }
        }
    } else {
        $err .= "Invalid login information. Try again!!!";
    }
}
}

function test_input($data){
    $data = trim($data);

```

```

    $data = stripslashes($data);
    $data = htmlspecialchars($data);
    return $data;
}
?>

```

### **Add production page**

```

<?php
include_once 'conn.php';
$error = "";
$message = "";

if (isset($_POST['btnSubmit'])) {
    $pcode = test_input($_POST['pcode']);
    $mcode = test_input($_POST['mcode']);
    $desc = test_input($_POST['desc']);
    $start_date = test_input($_POST['start_date']);
    $target_output = test_input($_POST['target_output']);
    $target_oeo = test_input($_POST['target_oeo']);
    $finish_date = null;
    $mach_status = "";
    $prod_status = true;
    $now = date('Y-m-d H:i');

    //Selecting machine status to check if not already running another production
    $sql = "SELECT status FROM machine WHERE mcode = '$mcode'";
    if($data = mysql_query($sql)){
        while ($row = mysql_fetch_assoc($data)) {
            $mach_status = "$row[status]";
        }
    }
}

```



```

if ($start_date > $now) {
    $serr = "Production start time can not be greater than the current time.";

} elseif ($mach_status == true) {
    $serr = "Selected machine is already active. Verify that previous production was ended.";
} else{
    $sql = "INSERT INTO production VALUES ('$pcode', '$desc', '$mcode', '$start_date', null,
true, '$target_output', null, null, null, null, null, null, null, '$target_oe' )";

    if(mysql_query($sql)){
        $sql = "UPDATE machine SET status = true WHERE mcode = '$mcode' ";

        if(mysql_query($sql)){
            $message .= "Record successfully updated .....<br>";
        } else{
            echo mysql_error();
        }
    } else{
        $serr .= mysql_error()."<br>";
    }
}
}

function test_input($data){
    $data = trim($data);
    $data = stripslashes($data);
    $data = htmlspecialchars($data);
    return $data;
}
?>

```

## Calculate machine daily OEE

```
<?php
include_once 'conn.php';
$machine_code = 10005;
$serr = "";
$message = "";
$today_start = date('Y-m-d')." 00:00:00";
$today_finish = date('Y-m-d')." 23:59:59";
$current = date('Y-m-d')." 00:00:00";
$sql = "SELECT production.pcode, production.description, production.mcode,
production.start_date, production.finish_date, production.status, production.breaks,
production.target_oeo, machine.nameplate_capacity FROM production, machine WHERE
production.mcode = machine.mcode AND production.mcode = $machine_code";
if($data = mysql_query($sql)){
    while ($row = mysql_fetch_assoc($data)) {
        $pcode[$counter] = "$row[pcode]";
        if ( ($today_start <= "$row[start_date]" && $today_finish >= "$row[start_date]") ||
($today_start <= "$row[finish_date]" && $today_finish >= "$row[finish_date]") ||
($today_start >= "$row[start_date]" && $today_finish <= "$row[finish_date]") ||
("$row[status]" == true)) {
            if ( $today_finish <= "$row[start_date]") {
                continue;
            }

            $voutput = 0;
            $vrejects = 0;
            $vdowntime = 0;
            $vbreaks = 0;

            //Retrieving rejects and output for the selected pcode
            $sql = "SELECT output, rejects FROM updates WHERE pcode = '$pcode[$counter]'
AND date >= '$today_start' AND date <= '$today_finish' ";
            if($data1 = mysql_query($sql)){
                while ($row1 = mysql_fetch_assoc($data1)) {
```

```

        $voutput += "$row1[output]";
        $vrejects += "$row1[rejects]";
    }
} else{
    $err .= mysql_error();
}
//Calculating performance
$performance[$pcounter] = (($output[$pcounter] / $operating_time[$pcounter]) /
$nameplate_capacity[$pcounter]);
$tperformance[$pcounter] = round(($performance[$pcounter] * 100),2);
$vperformance += $performance[$pcounter];

// Calculating quality
if ($output[$pcounter] < 1) {
    $quality[$pcounter] = 0;
    $tquality[$pcounter] = 0;
    $vquality += $quality[$pcounter];
} else{
    $quality[$pcounter] = ($output[$pcounter] - $rejects[$pcounter]) /
$output[$pcounter];
    $tquality[$pcounter] = round(($quality[$pcounter] * 100),2);
    $vquality += $quality[$pcounter];
}

//Calculating availability
$availability[$pcounter] = $operating_time[$pcounter] /
$planned_production[$pcounter];
$stavailability[$pcounter] = round(($availability[$pcounter] * 100),2);
$svavailability += $availability[$pcounter];

//Calculating actual OEE
$oee[$pcounter] =
$availability[$pcounter]*$performance[$pcounter]*$quality[$pcounter];
$toee[$pcounter] = round(($oee[$pcounter] * 100),2);

```

```
$voee += $oee[$pcounter];  
$vtarget_oeo += $target_oeo[$pcounter];  
  
//Calculating target vs actual OEE  
$difference[$pcounter] = $toee[$pcounter] - $target_oeo[$pcounter];  
$vdifference += $difference[$pcounter];  
  
}  
  
}
```