Performance Measurement of the Maintenance Function within Ecomold Ltd

Master thesis in Industrial Economy and Information Management

By

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Acknowledgements

The basis for this Master Project was an optional choice of subject within the field of the Industrial Economy and Information Management programme at Agder University College - Grimstad. As an exchange student at The University of Hertfordshire - UK the idea for the Master Project was proposed to me through my lecturer Mr. David Ashall by the Manufacturing Manager - Mr. Brian Bridge and the Maintenance Manager - Mr. Michael Ollivere, at Ecomold Ltd – Dunstable.

Ecomold Ltd is UK's largest independent plastic moulders within the automotive industry. Due to considerable busy days and years of plastic components manufacturing, opportunities to stop and measure performances of structures and routines have not been easy. After a hectic period, help from a graduate student with objective views and opinions was therefore of great interest. This gave me the opportunity to put 5 years of education to the test and I think that Ecomold Ltd was a brilliant point of departure to write a good Master Thesis, with the title:
Performance Measurement of the Maintenance Function within Ecomold Ltd.

The main challenge initially, was to find relevant theory from the field of maintenance, in addition to the literature which has been part of certain modules. Most literature found additionally was older than the original, but as the science of general maintenance routines has gone through limited changes through the latest years, I find the selection of literature of full satisfactory. Other challenges have been to link relevant theories to problem definitions, set in cooperation with the company and the project supervisor, and also, how to collect most relevant information possible about the current routines at Ecomold Ltd. In spite of a few doubts on how to approach certain problems, it has been very interesting to explore the field of maintenance within such a complex and hectic manufacturing environment. Therefore, the Master Project has in all respects been very exciting and instructive.

It is important to take notice of that this Master Project has two interested parties; Agder University College, and the employer Ecomold Ltd. I therefore have had to take consideration of both Agder University's guidelines on thesis writing, where I have to take consideration of scientific review – which in my case is a practical approach – and the company's wants and needs in the light of the problem definitions.

With helpful assistance from the Maintenance Manager – Michael Ollivere and Manufacturing Manager – Brian Bridge at Ecomold Ltd for allowing and arranging the project, Dr. S. Loke at the University of Hertfordshire for helpful tips on Microsoft Access, and project supervisor Prof. Arne Dag Sti at Agder University College for allowing the Master Project to be carried out abroad – I hereby thank you all for your help and support throughout this period.

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Ivar Homme Hansen

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Executive Summary

This Master thesis is an advisory report primarily directed to the maintenance department within the Ecomold Ltd organisation in Dunstable, UK. The content is based on the maintenance manager's request of a performance measure assessment of the department, and further the desire of designing a feedback system providing relevant data on planned and unplanned maintenance work.

This Master thesis is grouped into 8 main chapters: 1. An Initial Perspective, 2. Literature Review, 3. Methodology, 4. Research Findings and Analysis, 5. Feedback System, and 6, 7 and 8. - Conclusions, Recommendations, and Reflections on the Research.

Introductorily, a brief outline of the Ecomold organisation, included the maintenance department structure is presented.

Then, a thorough literature review is presented outlining optimal maintenance factors and strategies, including maintenance organisation, the maintenance programme, preventive maintenance, and finally, planning, scheduling and work execution.

Further, the methodology of the performance measurement assessment is explained, presenting arguments for the choice of approaches. Also, the maintenance evaluation questionnaire design is discussed.

Next, the results of the evaluation questionnaire are presented, including assessment of the research findings and analysis of the performance measurement of the maintenance function, based on the literature review.

In addition, brief theory about- and the results of the data feedback system design based on Ecomold's wants and needs are presented.

Finally, conclusions and recommendations to the various points mentioned, are given.

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CHAPTER 1 – AN INITIAL PERSPECTIVE

1.1 Introduction

Throughout this master project the student has acted as a “consultant” to assess the performance measurement of the maintenance function within Ecomold Ltd.

First, the importance of a good maintenance function and the focus a good evaluation of a maintenance function should include is described.
Ecomold Ltd is one of several manufacturing companies who have acknowledged the fact that strict customer demands on price and delivery has lead all plant departments to perform better than their best to meet daily targets. In such a busy environment, the importance of evaluating own routines and performances is therefore seldom possible to do.
This master project has therefore the objective of helping the maintenance department within Ecomold Ltd in measuring their performance and current routines compared to selected literature review. In addition, routines on the feedback record of maintenance work, both planned and unplanned, needs an upgrade, and so a new computerised system for this will be designed and implemented.

1.2 About Ecomold

Ecomold - Dunstable is part of the Ecomold Ltd Group, which also includes the sites Ecomold - Southend, Ecomold - Foxhills and Ecomold-Valls in Spain. With approximately 250 employees in the Dunstable plant, Ecomold Ltd is the UK's largest independent injection moulders and solid part of the worldwide injection moulding sector within the automotive industry.
Operating up to 34 injection moulding machines (See appendix 1) almost 24 hours a day – 7 days a week, Ecomold-Dunstable manufactures plastic components such as battery trays, door panels, bumpers, various plastic covers, child seats and a considerable number of other plastic components. These are supplied to worldwide

customers such as; BMW, Ford, Honda, Land Rover, Jaguar, Bentley and others. With a yearly turnover of £26,676,000 in 2005, Ecomold-Dunstable is constantly experiencing new commissions and the plants are busier than ever.

1.3 Maintenance Department Structure

In addition to the maintenance manager, the maintenance staff at Ecomold-Dunstable consists of 8 engineers and 3 apprentices. These are engineers with knowledge of mechanics, electronics and machine programming.

The work structure is based on 3 shifts (early, late and night) a day. This means 2 electrician engineers on each shift and 1 mechanical engineer on the early and late shift.

1.3.1 The Measurement Room

The Measurement Room is located in the heart of the plant. Here, all numbers and figures are displayed on their respective department boards. The purpose of this is making the overview as cooperative and clear as possible, leading the different departments to easier cooperating fully.

Data from the following departments are displayed:

- Health & Safety / HR
- Quality
- Business Unit 1
- Business Unit 2
- Logistics
- Process Engineering
- *Maintenance*
- Tooling
- NPI (New Product Introduction)
- Housekeeping

The room contains vital site specific production data and key information from all site departments. Hourly review meetings use this information to respond quickly to arising issues and to continually assess ongoing actions.

The Measurement Room is therefore viewed as a tool to ensure the continued improvement of each site's products and processes with the aim to expand and grow as a business and to exceed the customer needs.

1.4 Problem Definition

- *What is general optimal (theoretically and economically) maintenance strategy, and how do the current maintenance routines within the Ecomold organisation perform, reflecting on this question?*

This is considered to be the natural approach of the Master Project. It is in the Ecomold organisation's interest to investigate whether the maintenance routines are performing as optimal as possible.

- *How is the information on planned/unplanned maintenance routines going to be collected, and what information is relevant to collect?*

This question is important because it will ensure that the quality of feedback is as accurate as possible. Also, it will ensure that the information collected is useful.

- *What is the best way to feedback information to help prevention and solving of future issues?*

The Maintenance department wants a simple system which feedbacks relevant data of planned and unplanned maintenance carried out. This system will present e.g. descriptions, time spent, costs and causes involved in each maintenance operation and therefore give the Maintenance department a better foundation for decision making in future maintenance operations.

1.5 Approach to the problem

The approach of investigating how general optimal maintenance routines work will be carried out by doing literature review and presenting this in a well-arranged and logical structure. This will then be compared with the current maintenance routines. To collect data from current routines for comparison with the approach mentioned above, a quantitative method using a questionnaire will be used. Also, for additional collection of information on routines, a qualitative method interviewing personnel will be carried out. The data which is collected, both through the questionnaire and interviews, will be compared with the literature review to further assess the performance.

Finally, when it comes to feedback of information to help prevention and solving of future issues, the approach will be to design a simple but solid feedback system which can record and feedback relevant data. The application used will most likely be Microsoft Access which is suitable for this type of task.

1.6 Aims and Objectives

The main objective of this Master Project is to measure the performance of the maintenance department within the Ecomold Dunstable organisation.

This includes analysis of the type (planned/unplanned) and frequency of maintenance carried out on the key moulding machines and robots on-site, and assessment of information gathered compared to literature review. As a result, the aim will be providing the Ecomold organisation with strengths and weaknesses of maintenance routines, giving them a better foundation of considering and improving the current maintenance routines within the plant.

The further objective is to design and implement a suitable and appropriate collection system for data feedback on maintenance work (planned/unplanned) which will replace the current manual system routines. As a result, the aim will be to provide the maintenance department with a simple but solid feedback system which will generate clearer, better arranged and easier decision making for the Maintenance Manager in certain future issues.

1.7 Guidelines and Criteria

Aim	Criteria/description
Answer the problem approach	Focus throughout the whole report of sticking to the problem approach. It is important that the literature review deals with the subject. In addition, remove what is not relevant compared to the problem approach afterwards.
Delimitation	Pursuant to the time and number of pages of disposal, necessary delimitations need to be set so that the research can be in-depth, and not too general.
Literature review	Carry out thorough theory research and use the theory available.
References	Refer to source when a statement from the literature is given.
Methodology	Present the choice of method and document that the selected method is reasonable.
Results	Describe the most important findings and possible weaknesses.
Structure	A logic structure of the report pursuant to the problem definition.
Language	Good sentence structure and statements – logic coherence between sentences and sections.
Layout pursuant to guidelines	Use of correct font size and margins. Use tables and figures where useful.
Deadlines	Set secondary goals on the way of the work with the project, and achieve them. See appendix 2.

Table 1.7.1: Guidelines and Criteria

CHAPTER 2 – LITERATURE REVIEW

2.1 Background Information on the Literature Review

All literature review has mainly been taken from maintenance theory books and maintenance theory articles.

2.2 Maintenance Organisation

In order to go through with the performance measurement of the maintenance function within Ecomold Ltd, it is primarily natural give an outline of relevant theory within the area of industrial maintenance. In the following, central areas within maintenance, i.e. maintenance organisation, maintenance programme, preventive maintenance, and planning, scheduling and work execution are presented.

How should maintenance organise itself to best support the plant maintenance requirements? (Tomlingson, 1992)

In the following, key elements which need to be emphasised in order to adequately organise the maintenance function are presented.

2.2.1 Core Tasks

The general industrial maintenance organisation must be able to perform a multitude of tasks effectively. The main task is to support operations by keeping production equipment in good condition so that production targets can be met. Failures of meeting production targets have considerable consequences leading to customers finings for each component failed to be delivered. More generally, maintenance must also keep the plant site and its buildings, utilities and grounds in a functional condition. Further, maintenance must develop a programme for carrying out its services. They must organise themselves to support the equipment maintenance needs of production while conducting essential engineering projects. Perform quality work. Anticipate and prepare for future work. Also, achieve continued improvement by evaluating performance, taking corrective actions and measuring progress. Finally, maintenance should prepare for future changes by anticipating needs and organising flexibility.

2.2.2 Organisational Principles

In organising themselves, maintenance must successfully apply organisational principles (Tomlingson, 1992)

Maintenance must assign specific objectives to units to promote understanding and mutual support. They must keep different units of the organisation compatible so that they work harmoniously, and also, specify the functions to be performed. Further, it is important that maintenance allow the organisation to achieve efficiencies without imposing restraints. Maintenance should set common goals so that all employees know what is expected of them. It is also important that the maintenance task is divided so that each employee has an amount of work he/she can successfully handle. This means equalisation of responsibilities that commensurate with the ability of personnel to carry them out. Next, it is important to ensure that all know exactly what duties they are responsible for. Finally, a general organisational principle which is useful to fulfil is the ability to consider what is important or critical and what is not. If something takes care of itself, it should be left alone. This means; report *problems* rather than unnecessary confirmation of normal situations.

2.2.3 Trouble Signs

The danger signs of poor maintenance organisation often reveal that maintenance may accept tasks thrust on them and react rather than organise. This could be the consequence of not identifying the main objective, which is to maintain production equipment. Next, the work that must be done to achieve the correct maintenance objectives is rarely identified properly. Typically, without timely equipment inspections, surprises force emergency repairs and few problems are uncovered soon enough to plan the work. Further, maintenance often tries too hard to promote from within the organisation. A good mechanic does not always make a good supervisor. The best supervisors are those who control the work and effectively use the efforts of their crew members. Poorer supervisors try to work along side crew members thus, diminishing their control. When these supervisors are given bigger responsibilities, they are often not equipped to manage them.

Maintenance can be a thankless job. As a result, personnel outside of maintenance are not always anxious to join the maintenance organisation. Thus, qualified personnel are excluded in favour of those within maintenance who may be less qualified. Finally, it is emphasised the importance of that maintenance procedures must be based on policies. If not, few work effectively.

2.2.4 Contract Maintenance

Many plants use contract maintenance for all maintenance or to supplement the regular maintenance workforce during peak periods such as shutdown. One of the greatest appeals of contract maintenance is the ability to staff up when needed and reduce its size when not needed. However, contract maintenance will be expensive so it must be used wisely. The most effective contract maintenance appears where multiple plants find it convenient to shift contract personnel quickly between locations. The company manages the maintenance function with its own programme. It then controls the contract workforce trough the company's own key personnel from supervisors down to planners and maintenance engineers. The contractor provides field supervisors and craftsmen to execute the work. One should be aware of contractors who show up with "everything", including his/her own maintenance programme. Within a short time the programme is so imbedded in the plant's accounting procedures that the plant cannot get rid of the contractor even when they know they must.

2.3 Maintenance Programme

Is the maintenance programme defined so that maintenance personnel can perform it effectively, operations can use its services properly, and staff personnel will understand how to support it conscientiously? (Tomlingson, 1992)

2.3.1 The Production Strategy

The maintenance programme is an integral part of the plant production strategy – the overall plan by which plant departments work harmoniously toward a common objective of profitability. Within the company's strategy, each principal department should have a clear objective. All objectives should be mutually supporting and contribute directly to the common plant goal of profitability. Accompanying the objective are the policy guidelines which amplify its intent and spell out responsibilities to ensure the joint, cooperative efforts of plant departments.

2.3.2 Defining Maintenance

Guided by the assigned objective and policy guidelines, maintenance should establish day-to-day procedures and fit them into a framework depicting how maintenance services are requested, planned, scheduled, controlled, and measured. They should define terminology used to ensure that it is understood.

To adequately define the maintenance programme, the following should be provided:

- **An Objective**

  A clear statement of what maintenance is to do in supporting the plant's overall production strategy.

- **Policy Guidelines**

  Identification of specific roles and responsibilities which must be carried out by each department to ensure the maintenance programme can be successful.

Then, maintenance must:

- **Develop a concept**

  An overview of the maintenance programme detailing the specific manner, in which work is requested, planned, scheduled, executed, controlled, and measured.

- **Establish Procedures**

  Details to allow personnel to easily follow instructions for obtaining or carrying out maintenance services.

- **Define Terminology**

  Establish common maintenance terms to promote understanding.

Collectively, these elements constitute maintenance programme definition. Once the programme is defined an education programme must follow to ensure all appropriate plant personnel can perform it effectively, use its services properly, and support it conscientiously.

2.3.3 The Concept of Maintenance

Programme definition avoids confusion (Tomlingson, 1992)

For many years, different maintenance organisations have tried to find answers to how to define a perfect maintenance programme. But there are 10 core questions that *need* to be answered. If they are not, confusion, lack of control and poor maintenance result.

The 10 core questions are:

- How are maintenance services requested?
- Once received by maintenance, how do they go about responding?
- What keeps production from calling everything an emergency?
- What kind of work does maintenance plan?
- What criteria exist to distinguish non-maintenance from maintenance work?
- Who reports labour use?
- Who attends the scheduling meeting?
- How is work status reported?
- What is the maintenance engineer supposed to do?
- Who approves major work like overhauls?

Although many maintenance organisations actually have documented their programme, such documentation is seldom read. Less often is it the subject of an educational effort. The result is little clarity as to how the programme operates, what roles personnel play, how control is achieved, and how performance is measured.

2.4 Preventive Maintenance

What can be done to ensure effective preventive maintenance?
How should maintenance organize and conduct preventive maintenance services?
How can operations best support preventive maintenance?

2.4.1 Management Support

The most important step that can be taken to ensure the success of preventive maintenance is to establish policies that prescribe how maintenance is to carry it out and how operations are to support it. In appropriate policy, maintenance will conduct a "detection oriented" preventive maintenance (PM) programme. The programme will include equipment inspection and non-destructive testing (predictive maintenance) to help avoid premature failure. Lubrication, servicing, cleaning, adjusting, and minor component replacement will be carried out to extend equipment life. PM will take precedence over every aspect of maintenance except bona fide emergency work. Production will perform PM-related tasks, such as cleaning and adjustment, and ensure that all PM services due are carried out on time. Compliance with the PM schedule will be measured and management will be informed of performance improvements as a result of PM services performed. The purposes of PM as well as the requirement of production to support the programme and the interest in assessing compliance and benefits secured are demonstrated by such a policy.

2.4.2 Operations Support

Once the preventive maintenance programme has been organised, the operations manager should approve the PM programme recommended to him/her by the maintenance manager. He/she then ensures that his/her key personnel understand the programme and are aware of the supporting roles that they must play to ensure programme success. Operations supervisors should monitor the overall effect of the PM programme in reducing downtime. They should verify that scheduled PM services in their areas are carried out on time. Operations supervisors should require that maintenance inform them of deficiencies uncovered by inspections. Thereby, decisions can be made regarding the scheduling of equipment for repairs. Process engineers should verify that maintenance service checklists meet the technical needs of equipment operation and production processes. Operators should carry out tasks like cleaning and adjusting equipment or checking oil or hydraulic fluid levels. They can also help by operating equipment properly and reporting problems promptly. Since operators are on or near equipment continually, they can spot and report potential problems.

2.4.3 Understanding Preventive Maintenance

Preventive maintenance – Inspection and testing to avoid premature equipment failures and lubrication, cleaning, adjusting, and minor component replacement to extend equipment life. (Tomlingson, 1992)

PM services help to avoid equipment failures through the use of:

- Equipment inspections to uncover deficiencies before failure and in sufficient time, plan deliberate repairs.
- Non-destructive testing techniques (predictive maintenance) to detect equipment deterioration and monitor equipment condition to note abnormal operation.

Collectively, these activities are called *condition monitoring.* In addition, preventive maintenance services preserve equipment life with:

- Lubrication to reduce friction that causes heat, wear, misalignment, or seizure.
- Routine cleaning and adjusting done in conjunction with inspection or lubrication, or performed by operators.
- Replacement of minor components to reduce chances of more important components failing.

Preventive maintenance should not include major repairs. It is a "detection oriented" activity aimed at uncovering problems before equipment failure and providing sufficient lead time to plan selected work. To avoid confusion, it could be best to refer to PM as "preventive maintenance services".

2.4.3.1 Philosophy

At the outset of the PM programme, inspections will identify many needed emergency repairs because a special effort is being made to find problems before equipment fails. If the emergency repairs are made promptly, their volume will soon diminish. Then, as inspections continue, the nature of the deficiencies will gradually change. There will now be more unscheduled repairs and fewer emergencies. Some of the unscheduled repairs will be larger which could be both planned and scheduled. However, it is important that a planning capability exists. As the planning capability increases, there will be a further reduction in unscheduled repairs. Many such jobs will meet the criteria for being planned. Thus, the pattern of work generated by PM inspections will change over time. (See fig. 3-1) These improvements will be dependent on consistent inspections and testing together with the establishment of an effective planning staff.

Beyond 18 months, the deficiencies yielded by inspection and testing will stabilise, in terms of manpower used, at about 10% emergency repairs and 20% unscheduled repairs. Work that can be both planned and scheduled will gradually increase to utilise 40 to 50% of total maintenance manpower. Subsequently, inspections and testing will yield more information on component conditions than on deficiencies. As this happens (approximately 24 months), a periodic maintenance forecast should be introduced to project future major components replacements The accuracy of the forecast depends, of course, on the quality of repair history data (component life span) from which forecasts are developed. As component replacements are identified, the most recent PM inspection results should be reviewed to determine the actual condition of the component being replaced. (See fig. 3-2)

2.4.3.2 Scope

The preventive maintenance programme should be applied selectively to production equipment, buildings, and facilities. Production equipment should be included in the programme based on a high probability of failure and serious consequences of failure. Typically, a one of a kind unit of production equipment whose failure will stop operations is a primary candidate for inclusion in the PM programme.

2.4.3.3 Objectives

Preventive maintenance services have the following objectives:

- **Reduction of Emergency Repairs**

  Equipment inspection and testing ensure that maintenance is aware of equipment condition and can act to prevent premature failures. By uncovering problems early, emergencies are adverted and more deliberate repairs can be conducted.

- **Reduction of Unscheduled Repairs**

  Unscheduled repairs should be reduced. Timely PM inspections identify problems sooner while they are correctable as adjustments or minor component replacements.

- **More Planned and Scheduled Work**

  Successful PM inspections yield more lead time for planning. As a result, more work can be planned.

- **Better Manpower Utilisation**

  As a result of more planned work, productivity on the job is increased because the work was better organised beforehand.

- **Reduction in Repair Costs**

  Emergencies and unscheduled repairs are replaced with more planned work. Because work was organised in advance, labour use is more productive, and less labour is required. Thus, labour costs are reduced.

- **Reduced Downtime Cost**

  Downtime costs 3 times the cost of performing the maintenance work that could have avoided it. By effectively planning and scheduling the job, a 6% reduction in elapsed downtime can be realised. The ability to plan derives from PM.

- **Preservation of Assets**

  Well cared for equipment, buildings, and facilities last longer.

2.4.4 Maintenance Actions

Maintenance must ensure that the PM programme functions in conjunction with other elements of its programme.

This includes:

- **Work order system**

  A standing work order is normally used to denote PM services because they are routine, repetitive activities.

- **Planning**

  Once PM services are determined, their frequencies established and checklist prepared, the planning related to PM execution is done. On the other hand, deficiencies identified when equipment is inspected often yield work that requires planning.

- **Scheduling**

  PM services for fixed plant equipment are scheduled routinely and repeated at regular, fixed time intervals such as weekly and at four weeks.

- **Information system**

  The information system provides feedback on whether or not PM services are carried out on time. It also reports compliance with the PM schedule as well as changes in labour use, costs, or downtime as a result of performing PM services.

2.4.5 Preventive Maintenance Procedures

PM services for fixed production equipment should be scheduled at fixed intervals such as weekly, biweekly and monthly. Services should be carried out on a routine, repetitive basis. This means that the service is guided by a checklist each time that it is carried out, making it a routine activity. It should also be performed at a regular service interval, making it repetitive.

2.4.5.1 Conduct of Services

There should be no repairs made as the PM services are carried out, only cleaning, adjustment, and minor component replacements. Unless such a policy is followed, many inspections and services are never completed. Electrical and mechanical PM services should be conducted simultaneously to reduce servicing time as well as downtime. Services should be guided by a checklist. As the service is carried out, the checklist guides personnel through the service to ensure that nothing is missed. The checklist is a guide. Each checklist should be backed up with a detailed training manual explaining how the service is performed. As necessary, the manual should contain pictures of components so that personnel can see the details.

2.4.5.2 Required Services

PM services include inspection, non-destructive testing and lubrication. The principal emphasis should be given to equipment inspection and testing so that the condition of equipment can be monitored and deficiencies can be found. The sooner deficiencies are found, the greater the impact on reducing emergencies. Also, by finding problems sooner, the lead time before the repair is required is longer making it possible to plan more work.

2.4.5.3 Service Frequencies

PM service frequencies are based on the manufacture's recommendations, experience and reliability needs. Service frequencies should be adjusted based on equipment performance. Typically, if a one week fixed equipment inspection interval produces no deficiencies, the interval should be extended to 2 or 3 weeks.

Each moulding machine should have a range of services built on increments of accumulated hours.

2.4.5.4 Downtime

The total equipment downtime is, for example, downtime debited against maintenance. It is measured from the time the unit is in the hands of the maintenance department until the unit is released. It includes cleaning, inspecting, servicing, testing and minor component replacement. To minimise service time, an equipment facility should provide bays used exclusively for PM (for mobile equipment). Extensive repairs should be made in other bays. Materials such as belts, filters, gaskets and so forth, should be pre-packaged before the service begins to save time. Helpers should be used on lesser tasks such as filter replacements in order to keep the craft personnel on the more demanding aspects of the service.

2.4.5.5 Identification of Services for Fixed Equipment

The standing work order (SWO) is appropriate for control of routine, repetitive preventive maintenance services. An SWO represents a specific preventive maintenance service for fixed equipment. It links the service to the cost-centre in which it is carried out.

2.4.5.6 Service Routes

PM services for fixed equipment should be linked together in routes by cost-centre based on types of services and similar frequencies. Every unit in a cost-centre requiring a weekly inspection should be placed on the same route, for example. The path between units should be arranged for minimum travel time. Time for discussion with operators and supervisors should be built into routes. Maintenance supervisors should walk each route with the craft personnel who will carry out the service. They should orient them on the service and verify that they understand the PM concept. The checklist should be explained, servicing techniques demonstrated, and the route discussed.

2.4.5.7 Focus on Cost-Centres

Each PM route should be carried out within a cost-centre so that manpower used and costs can be attributed to the cost-centre. It also permits the effectiveness of the services to be more readily evaluated.

2.4.5.8 Pre-PM Actions by Operations

Once notified of the date of the PM service, equipment operators on all shifts should record any problems that they observe to ensure that they are called to the attention of maintenance personnel.

2.4.5.9 Actions Required Once Definitions Are Known

It is important to ensure that maintenance acts immediately to correct deficiencies found by inspection and testing. An excellent motivator is to require them to advise operations first. Operations will then follow up to ensure that all serious deficiencies are corrected. Emergency repairs should be corrected immediately. Unscheduled repairs should be recorded so that they can be performed at the first opportunity. Work requiring planning should be assigned to the planner without delay.

2.4.5.10 PM Workload

The man-hours, by craft, required for PM should be established. For example, a PM inspection route for fixed equipment performed by an electrician once a month at 3 MH (man-hours) per occurrence requires 26 MH per year. If all such routes were computed, the total MH per year by craft could be determined for all PM services carried out in a given cost-centre. As actual man-hours are reported, estimates are verified.

2.4.5.11 Compliance with the PM Programme

Management should receive a weekly PM compliance report. The report should state the percent of services completed versus the number scheduled. Services not completed should be identified so that actions may be taken to reschedule them.

2.4.5.12 Measuring PM Success

A criterion should be established for monitoring the success of the PM programme. This should include:

- Reduction in emergency repairs
- Increased scheduled maintenance
- Reduction in unscheduled repairs
- Increased equipment life
- Extended time between repairs
- Long-term cost reduction

2.4.5.13 Keeping the PM Programme Up-to-Date

New equipment should be added to the PM programme promptly and the adjusted workload checked to ensure that sufficient man-power is available. Similarly, obsolete equipment should be withdrawn and adjustments made in the workload. Equipment that will be phased out should have its services gradually diminished.

2.4.5.14 Responsibilities

A single person should be responsible for the overall development, administration and monitoring of the PM programme. The maintenance engineer is a good choice. The programme should be launched as quickly as possible even if check sheets are not complete or routes have to be adjusted later.

2.4.5.15 Credibility is at Stake

> Maintenance must produce tangible results like reducing emergencies and not talk about what they are going to do. *(Tomlingson, 1992)*

2.4.6 Lubrication

Lubrication has the objective of extending equipment life. It is organised and administrated the same way as other elements of the PM programme. There are lubrication routes, checklists, service frequencies, service times and so on. The difference is that performance of the service, not detection of problems, is the main objective. Also, there is a higher degree of potential production operator involvement in checking oil and hydraulic fluid levels at short intervals of every shift or every day. However, operators must be trained if they are to do this effectively.

2.4.6.1 Oil Sampling

Oil analysis reveals the internal condition of equipment as evidenced by microscopic fragments of steel, bronze, iron and so on, in the oil. The degree of these fragments reveals, in turn, the amount of wear and signals the state of equipment deterioration.

2.4.7 Non-Destructive Testing

Non-destructive testing, also called predictive maintenance, determines equipment condition through the use of testing techniques. These services are administrated the same way as other PM services with routes, frequencies, checklists and so on. They also produce equipment deficiencies which must be converted into corrective actions. Testing devices must be calibrated to ensure accuracy. Testing compares a current condition with a normal operating condition to identify problems.

2.5 Planning, Scheduling and Work Execution

What are the essential planning steps?
What type of jobs should be planned?
How can one ensure that planned work is done with the least interruption to operations while making the best use of maintenance

Planning major jobs assures productive use of resources, providing the work is scheduled at the best time and, its execution is properly controlled. Important definitions are:

- **Planning**

  Organising resources in advance of major job, so that, upon execution, the work may be carried out more effectively.
- **Scheduling**

  Determining and confirming the best time to perform a major job with least interruption of operations and effective use of maintenance resources.

The ultimate purpose of planning is to organise maintenance resources in advance so that when the work is done it can be carried out more effectively. The ultimate purpose of scheduling is to ensure that planned work is done with the least interruptions to operations while making the best use of maintenance resources.
Planned work is done more deliberately. Planning improves the productivity of those doing the work and the quality of their work. It also allows the work to be completed in fewer man-hours and less elapsed downtime. Proper scheduling assures that the best, most convenient time is selected. Thus, there are fewer interruptions. Together, good planning and scheduling achieve better resource use and quality work, reduced downtime, and lasting repairs. While all jobs require some level of planning, the best use of planners is on major jobs that use the most resources. There should be criteria for determining which jobs should be planned.

2.5.1 Policies

The biggest portion of maintenance cost derives from labour and materials used on major jobs. When major jobs are properly planned and scheduled, the benefit is reflected in more productive use of personnel yielding lower labour cost per job and reduced downtime. Ordinarily, the cost of materials installed would be the same for either planned or unplanned jobs. However, such benefits only accrue when operations, maintenance and supporting departments like warehousing cooperate fully. As the maintenance manager, one should expect such cooperation. However, the reality is that cooperation is better assured with the maintenance manager's guidelines.

One should consider the following guidelines:

- A criterion will be developed identifying the type of work that will be planned and scheduled.
- A priority system will be applied to all planned and scheduled work specifying the importance of each job so that resources can be allocated. In addition, it will establish the time within which the work is to be done so that scheduling goals are established.
- All planned work will be jointly scheduled with operations to ensure that the best use is made of maintenance resources while ensuring that the work is performed when it least interferes with operations.
- Upon completion of a scheduling period (usually a week), scheduled compliance will be measured to ensure that both operations and maintenance have made a maximum effort to see that the scheduled work has been accomplished. Management will be advised of performance.
- Planners will focus their efforts primarily on planned and scheduled work. They will not be used to support unscheduled or emergency work except in unusual circumstances and then, only when authorised by the maintenance manager.

Guidelines such as these allow maintenance to develop procedures. In turn, common procedures assure understanding and cooperation.

2.5.2 Planning Criteria

There should be a criterion for determining which jobs should be planned and scheduled. With a criterion, the maintenance manager knows when the planner should help and the planner agrees. In a typical criterion, the work must be planned and scheduled if:

- Cost and performance must be measured
- A standard must be complied with
- Warranty work is being done
- Work must be started and completed within a specific period

2.5.3 Planning

Planners confer with the supervisors on who will perform the work as the plan is being developed. Once the planned work is scheduled, planners should monitor ongoing work and assist supervisors in coordinating work related activities such as on-site delivery of materials.

2.5.4 Supporting Roles

Maintenance and operations can make planning successful through proper use of planning.

2.5.4.1 Maintenance Department

Maintenance should execute planned and scheduled work based on the approved schedule. During the planning stage, they would confer with the planner to become familiar with job aspects and make recommendations on the method of job execution. The following list is an overview of typical responsibilities:

- Assist the planner in field investigations or the interpretation of standards.
- Confer with the planner on task sequences, use of labour, availability of materials, mobile equipment needs, and so on, to ensure that the plan is practical.
- Execute the weekly schedule through crew members and coordination with the planner.

- Explain significant variances from the plan and recommend changes for future repetitions of similar jobs.
- Ensure correct, accurate, timely reporting of field data on each job.

2.5.4.2 Operations Department

The operations department must understand the planning and scheduling sequence and appreciate the benefits of successfully planned work.

Their duties include the following:

- Approve work orders based on estimated cost and timing.
- Help establish job priorities.
- Approve the tentative weekly plan presented by maintenance.
- Participate in the weekly scheduling meeting and approve (or modify) the schedule recommended by maintenance.
- Make equipment available according to the approved schedule.
- Participate in daily coordination meetings and, as necessary, adjust the availability of equipment to better meet the schedule.
- Observe schedule compliance as well as job cost and performance.

CHAPTER 3 – METHODOLOGY

3.1 Choice and Discussion of Research Methodology

To ensure the best possible quality of methodology approach in collecting data for the performance measurement of the maintenance function within Ecomold Ltd, it is necessary to decide which method is the most relevant compared to the type of information which is to be gathered.

3.1.1 Quantitative Methodology

Quantitative data refers to all data which involve numerical data or contain data that could usefully be quantified to help answer research questions and meet current objectives. Quantitative data can be a product of all research strategies, and it can range from simple counts such as the frequency of occurrences to more complex data such as test scores or prices. To be useful these data need to be analysed and interpreted. Quantitative analysis techniques assist this process. These range from creating simple tables or diagrams that show the frequency of occurrence through establishing statistical relationships between variables to complex statistical modelling. If desired, quantitative data can be collected in standardised ways.

3.1.2 Qualitative Methodology

When looking closer at the data produced by qualitative research it is possible to draw some significant distinctions from those that result from quantitative work. These are helpful in terms of understanding what is necessary in order to be able to analyse these data meaningfully. Qualitative data are characterised by their richness and fullness based on the opportunity to explore a subject in as real a manner is possible.

The nature of qualitative data has implications for both its collection and its analysis. To be able to capture the richness and fullness associated with qualitative data they cannot be collected in a standardised way.

3.1.3 Strengths and Weaknesses of Methodologies

Strengths and weaknesses of the two most common approaches; *qualitative* and *quantitative* methods are presented in the following.

A contrast can be drawn the ‘thin’ abstraction or description that results from quantitative data collection and the ‘thick’ or ‘thorough’ abstraction or description associated with qualitative data.

Although qualitative methodologies may have greater problems with reliability than quantitative methodologies, the position is reversed when the issue is validity. The weakness in quantitative research is that the more tightly controlled the study, the more difficult it becomes to confirm that the research situation is like real life. The very components of scientific research that demand control of variables can therefore be argued as operating against external validity and subsequent generalization maintain that the more similar the research experiment is to the natural setting the greater is the validity and thus generalization of the findings. The strength of qualitative research is proposed in the claim that there are fewer threats to external validity, because subjects are studied in their natural setting and encounter fewer controlling factors compared with quantitative research conditions. Researchers also tend to become so immersed in the context and subjective states of the research subjects that they are able to give the assurance that the data are representative of the subject being studied. Paradoxically, the closeness of researchers also threatens the validity of the study if they become unable to maintain the distance required to describe or interpret experiences in a meaningful way. It is argued, however, that this is worth risking because of the high level of validity achieved by employing qualitative methodologies.

Although quantitative and qualitative methods are different, one approach is not superior to the other; both have recognized strengths and weaknesses and are used ideally in combination. It can therefore be argued that there is no one best method of developing knowledge and that exclusively valuing one method restricts the ability to progress beyond its inherent boundaries.

3.1.4 Selected Methodology

The maintenance literature suggests that a combination of quantitative and qualitative methodology in collecting data on maintenance routines provides the most complete coverage. This will there be the choice for further work.

3.2 The Questionnaire Design

Representing the quantitative methodology, a questionnaire, attached as appendix 3 will be handed out to all maintenance personnel. Main points within the area of *preventive maintenance* will cover the maintenance *programme*, the *organisation*, and the *environment*.

The number of years of experience of the respondent will be separated and the statements are given scores from 1 to 7, where 7 is the best score.

3.3 Key Personnel Interviews

Representing the qualitative methodology, a physical audit will be carried out. This will examine the maintenance organisation and its programme further, as well as preventive maintenance routines, planning, scheduling and work execution.

CHAPTER 4 – RESEARCH FINDINGS AND ANALYSIS

4.1 Responses from Questionnaire

Of a total of 8 permanent employed engineers and 3 apprentices, 6 engineers were able to respond to the questionnaire. Full each experience group results and total results can be found in appendix 4. Table 4.1.1 below; shows a brief summary of the results.

↓ Category Experience →	2-5	6-10	21-30	Average
Programme	*3,37*	*3,04*	*4,80*	***3,74***
Organisation	*3,72*	*4,67*	*4,33*	***4,24***
Environment	*4,81*	*2,33*	*2,75*	***3,30***
Average	***3,97***	***3,35***	***3,96***	***3,76***

Table 4.1.1: Questionnaire results summary

The average score of all questionnaire responses is 3.76 out of a possible 7. The results show that there are quite clear differences between the age groups or length of experience, in what they see as strengths and weaknesses of the routines.
Figure 4.1.1 below shows the average rating of answer on each respective question compared to the average 3.76 which is drawn with a blue line.

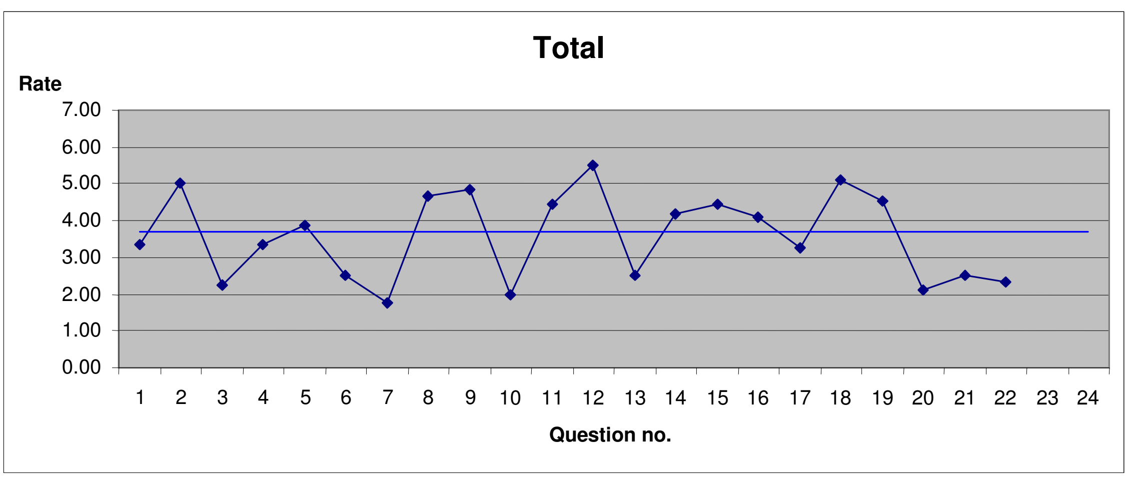

Figure 4.1.1: Questionnaire results summary graph

4.1.1 Analysis

Based on the questionnaire results, the performances of the following maintenance factors need improvements:

- **Keeping the PM programme up to date**
  The PM programme needs to be reviewed periodically and updated to reflect changing conditions.
- **Cooperation between operators and maintenance**
  The PM programme needs to be explained to operating personnel to enable them to cooperate and use its services effectively.
- **Feedback system**
  Each PM action needs to be identified by a code or number to aid in scheduling, control, and reporting.
- **PM services routes**
  The PM services for individual units of fixed equipment must be linked together in routes to avoid unnecessary travel time or backtracking.

The following maintenance factors are strength factors:

- **The timing of PM services**
  The timing of PM services needs to be carefully regulated according to fixed time intervals or accumulated operating hours.
- **Safety**
  The PM programme must emphasise safety.
- **PM programme intention**
  The PM programme must be oriented toward uncovering deficiencies before equipment fails.

4.2 Performance Assessment

This section will assess the performance of the maintenance function within Ecomold Ltd. The following evaluation and measurement is based on and compared with the literature review presented in chapter 2.

It is emphasised that the performance assessment of the maintenance function routines would have needed much more time than the length of this master project in being able to present and evaluate pure technical measurements such as measuring the benefit of a certain maintenance strategy in preference to other strategies.

The following performance assessment of current routines and structures is therefore mainly compared with the literature review presented in chapter 2.

4.2.1 Organisation

The organisational performance of the Ecomold maintenance department (herby referred to as 'maintenance') is measured on the basis of the questionnaire, observations and interviews with staff.

4.2.1.1 Organisational Principles

Maintenance personnel generally, often feel that attitudes towards them elude them as an "unwanted cost". This undervaluation of maintenance could in the long run have great impact on the work environment as a whole. To a certain degree, the current maintenance staff sees this as unfortunate.

The work harmony in maintenance is very good. However, the maintenance staffs are not optimally self-driven when it comes to achieving efficiencies on their own initiative without having to imposing restraints on them. With the maintenance manager absent for a certain period of time, general routine inspections are generally well performed, but the actual focus and initiative on achieving efficiencies and working towards the objective of preventive maintenance has a tendency to fade out.

The common goals within maintenance, in the sense that all employees know what is expected of them, are fairly present. However, as mentioned above, the overall common goal should be to work towards the *objective* of PM.

Although the working day can be considerably busy, the equalisation of responsibilities in carrying out tasks that commensurate with the ability of the

personnel knowledge and experience, functions well. The maintenance manager is clear in selecting the right engineer for the right job.
Finally, maintenance's strategy in considering the grade of importance of work needed to be carried out works very well using the measurement room.

4.2.1.2 Trouble Signs

Danger signs of poor maintenance organisation, as described in chapter 2.2.3 where personnel react rather than organise when tasks are thrust upon them, is to a certain extent the case within the maintenance department. This suggests that the main objective has not been properly identified, which is to continuously maintain production equipment.
Next, it seems that crew members often need to be worked along-side with to "get going". Being worked along-side with makes them perform better, but should optimally not be necessary when considering the importance of fully using the efforts of crew members.
Finally, the maintenance procedures are to a certain extent based on policies which the literature does suggest that it should. However, if these policies were documented and emphasised more clearly and more often, one should be able to see that crew members work more effectively.

4.2.1.3 Contract Maintenance

Currently, Ecomold does not shift contract personnel between the 3 locations spread in the UK. Still, contract personnel are hired for each individual plant during extra busy periods. It is important that these craftsmen do not show up with their own maintenance programme. However, Ecomold is at the same time interested in their advice, so there has to be a balance when deciding how to approach this.

4.2.2 Maintenance Programme

The maintenance programme performance is measured on the basis of the questionnaire, observations and conversations with staff.

4.2.2.1 Maintenance Definition

Although there is an "unwritten objective" in the maintenance department saying: "keep the plant running", there is no clear statement of what is to do in supporting the plant's overall production strategy. Accompanying the objective are the policy guidelines which amplify its intent and spell out responsibilities to ensure the joint, cooperative efforts of plant departments.

The policy guidelines – day-to-day procedures within requested services, are often held back because of financial matters. A balance for this has therefore been necessary to compromise. However, identification of specific roles and responsibilities to be carried out within the department is necessary to ensure a successful maintenance programme.

Defining technical terminology has not been prioritised but the crew members are all on a level were technical issues can be explained and there will be no misunderstanding of the information given. Establishing common maintenance terms to promote understanding is important, and purely technically terminology has not proven to be a problem within the maintenance department.

4.2.2.2 Maintenance Concept

To avoid confusion, lack of control and poor maintenance, there are certain key points within the concept of maintenance that need to be measured.

Currently, maintenance services are requested by operations by filling out an "Engineering Work Request Sheet". (See appendix 5) This is then handed to maintenance. The most relevant information is also displayed on the maintenance board in the measurement room for further discussion.

The actual maintenance service *requests* work quite well. But the problem with the current system is that it is awkward to go back in time and look at previous work carried out and take advantage of this information in future decision making. The *feedback* part of it is therefore quite poor.

Once the request is received by maintenance, and maintenance manager has displayed necessary information in the measurement room, he then chooses an appropriate engineer, based on the experience and the knowledge the engineer would have on the relevant problem to carry out the task given. When the job is completed the "Engineering Work Request" is finalised and filed.

When it comes to production and their yield on emergency works the tendency, from the maintenance point of view, is that almost everything is referred to as an emergency. However, it is quite typical for manufacturing plants that production is very self-focused and shouts out for only minor issues. However, one must not forget that maintenance is a *service for production* and not the other way round.

The following type of work is planned by maintenance:

- Total preventive maintenance - Machine
- Total preventive maintenance - Robot
- Mechanical work
- Electrical work
- Barrel calibration
- Risk assessments

Maintenance also performs non-maintenance work. Removing machines and installing other- or new machines is distinguished from normal maintenance procedures and would therefore fall under the non-maintenance category.
When a maintenance service has been carried out it is the engineer's responsibility to "deliver" the machine back to operations. The maintenance manager reports labour use.
The scheduling of maintenance meetings are attended by the maintenance manager and the planning manager. If work is scheduled by the maintenance manager only, then this is reported to the planning manager.
Work status is reported in the measurement room and this seems to work well.
Generally, major work like overhauls is sent to the manufacturing manager for approval. If the costs are of considerable values the approval is forwarded to the factory manager.

4.2.3 Preventive Maintenance

4.2.3.1 Operations Support

The PM programme is approved by the operations manager. He monitors whether it is to satisfaction and he is heavily involved in these issues.
Maintenance informs operations of deficiencies uncovered by inspections on the board in the measurement room. This works well because it is updated every hour through the day.

The maintenance services meet the technical needs of equipment. This is identified by the engineering checklists. An example of this can be found in appendix 6.

Most operators do not carry out tasks like cleaning and adjusting of equipment or oil / hydraulic fluid levels checking. This is done by the setters who are responsible for making sure that the machines are up and ready for a shift or a new start of product. The literature presented in chapter 2 clearly emphasises that operators should carry out tasks like cleaning and adjusting of equipment or checking oil or hydraulic fluid levels.

Also, careless treatment of equipment by operators may need improvement, in the maintenance department's view. The operators are not proactive in looking for obvious faults even though they are near the equipment continually.

4.2.3.2 Preventive Maintenance Generally

Maintenance performs PM inspections quarterly. (4 times per year) Some of these involve non-destructive testing techniques as *thermo-graphic analysis, oil-analysis* and *ultra sonic strain testing.*

Replacements of minor components (except filters) to reduce chances of more important components failing is not carried out because it is held back by financial matters.

The literature suggests that when PM is carried out, major repairs shouldn't take place at the same time but currently that is the case. The argument for doing this however, is that it saves time. The idea of having to shut down a machine twice when most possible work can be carried out in the first place seems to be quite waste of time. The argument for the literature's opinion is that unless such a policy is followed, inspection- and service routines are rarely followed.

Ideal PM

As a result of PM there should be less emergency repairs. This has also proven to be the case for Ecomold. Maintenance has several times found allusions on machines that they knew would have caused serious damage if PM work had not been carried out in advance.

The importance of reviewing components condition after they have been fitted in later PM work is carried out depending of the component type.

Scope

Buildings and facilities are not included in the *PM* programme. The literature suggests that it should. The argument for not including it is the importance of doing what you know, and leaving other kind of disciplines to they who master them best. At Ecomold, PM of buildings and facilities is carried out by the site- and facilities department.

Selectively prioritising PM services on certain machines more than other machines is not carried out, as the literature suggests that it should. All machines are treated equally but certain machines are harder to get access to because of busy production.

Objectives-fulfilment

Successful PM inspections should lead to more time for planning. This is currently not the case and could either be as a result of poor PM *or* that the workload is too high anyway. (The workload *is* considerably high)

Successful PM inspections should also lead to reductions in labour costs. Because PM has always been carried it would be hard to measure it. And, with a time scope of only 4 months for this project it would unfortunately not be possible to measure.

4.2.3.3 Maintenance Actions

When deficiencies are identified during PM inspections it usually leads to work that requires planning. Planning is organised by the maintenance manager in cooperation with the planning manager and planning results are displayed on the maintenance board in the measurement room. This way, the production department can adjust its schedule in meeting production targets.

4.2.3.4 Preventive Maintenance Procedures

PM services for fixed production equipment are scheduled to be carried out quarterly.

Conduct of Services

Electrical and mechanical PM services are not conducted simultaneously to reduce servicing time as well as downtime. However, mechanical work and robot work is. Electrical work, like calibration is done during weekends when most machines are shut down.

The PM services are guided by a checklist each time it is carried out. However, it is not backed up with a detailed training manual as the literature suggests, nor explaining how the service is carried out or containing pictures of components showing details. On the other hand, the checklists are very self-explainable. (See example in appendix 6)

Required Services

Ecomold has the following priority of the following key PM actions:

1. Lubrication
2. Inspection
3. Non-destructive testing

Service Frequencies

The literature suggests that PM service frequencies should be based on the manufacture's recommendations. Currently there is a combination of recommendations and their own experience.

If a fixed equipment inspection interval produces no deficiencies, the interval is then often extended. An example is the change of oil filter.

If a machine has an increase of accumulated running hours, PM services are then more frequently carried out and its condition is watched carefully. Machine number 14/2 is a good example of this and has been run harder than other machines.

Downtime

Downtime is considered to be from the time the unit is in the hands of maintenance and until the unit is released back to operations. Downtime is sometimes extended to the shift length of the engineer who carries out the PM service. Although some PM services do not take that long (normally around 4 hours) they are considered to last as long as a work shift. (8 hours)

Because most equipment is fixed, the PM services are carried out where the equipment is stat ionised.

Regarding mobile equipment, maintenance does not separate areas with PM work and extensive repairs.

Occasionally, parts are pre-packed before a service starts which is done to save time.

When it comes to job delegation, all engineers do the same type of work. If a PM service does not require a lot of skills and experience to be carried out, it is just as likely an apprentice as an experienced who carries out the job.

Service Routes

The PM services are to a certain extent linked in routes and that is within each shop. However, it does not always work like that. It is emphasised that linking PM services in routes, it could save time.

Pre-PM Actions by Operations

Equipment operators on all shifts should record any problems that they observe to ensure that they are called to the attention of maintenance personnel when a PM inspection is coming up. This is not carried out. If this had been carried out, it could save the maintenance crew for a lot of time in identifying those problems.

Actions Required

When deficiencies are discovered by inspection and testing, maintenance then reacts immediately and puts the problem on the board in the measurement room. It is then a part of planned work.
Sudden unplanned work is also administrated by displaying it on the board in the measurement room. This is then also part of planned work and planned further.

PM Workload

The man-hours required for a PM service on a press machine have been established. It is considered that 1 shift is needed per machine.

Measuring PM Success

As mentioned in the literature review, criteria should be established for monitoring the success of the PM programme:

- **Reduction in emergency repairs**
  Through the years, downtime has declined.
- **Increased scheduled maintenance**
  There has been an increase in scheduled maintenance.
- **Reduction in unscheduled repairs**
  There has to a degree been a reduction in unscheduled repairs.

- **Increased equipment life**
  There has been less downtime.
- **Extended time between repairs**
  There has been an increase in time between repairs.
- **Long-term cost reduction**
  There are no signs of long-term cost reduction, but it is worth the minor downtime which has been achieved by spending more money on PM.

Keeping the PM Programme Up-to-Date

In contrast with the maintenance crew's opinion, some new equipment is added to the PM programme promptly. It is also taken care of by the seller first, so that it is made sure that it is in perfect condition when taken over by Ecomold.

The adjusted workload is checked as well as possible to ensure that sufficient man-power is available. However, there is so much work to do that it can not get much lower than it all ready is.

Equipment that will be phased out does not, as the literature suggests that it should, have its services gradually diminished. That kind of equipment is spent more time on to make sure it stays fit and up-and-running. This is a financial issue. If there is no assets for a new machine anyway, one *will* have to take good care of the older machine and spend time on it to avoid breakdown with considerable consequences.

4.2.3.5 Lubrication

The operators are not trained to check oil and hydraulic levels at set intervals or every day. This is carried out by the setters. 5 employees on each shift who are responsible for starting up the machines and make sure that they are in fit condition for running.

4.2.3.6 Non-Destructive Testing

Non-destructive testing such as thermo-graphic analysis, oil-analysis and ultra sonic strain testing are techniques that are carried out on machinery to discover "hidden" faults or errors.

4.2.4 Planning, Scheduling and Work Execution

To ensure that planned work is done with the least interruptions with operations, maintenance has a close cooperation with the planning manager. This is also presented in the measurement room.

Criteria for determining which services should be planned are whether the services will have affects on the performance of the productivity.

4.2.4.1 Policies

The cooperation between maintenance, operations and other departments in general planning is considered to be on average level. The maintenance department is a *service* but other departments could also be more flexible in helping back.

There is no priority system in the planning for which machines are most important. All machines are treated equally on that basis.

As mentioned in the literature review, work should be performed when it least interferes with operations. PM work does not interfere much. Other maintenance work unplanned repairs would off course do that.

The scheduled compliance is measured to ensure that both operations and maintenance have made a maximum effort to see that the scheduled work has been accomplished, by using red and green colours for positive and negative numbers on the boards in the measurement room. This is advised to the management and monitored.

4.2.4.3 Planning

An important point may be that the maintenance manager could be relieved with certain planning work by the planning manager. As of how this works currently, the maintenance manager does not actually have time for planning. He will be to busy in dealing with unplanned repairs and emergency issues.

4.2.4.4 Supporting Roles

The operations department should:

- **Approve work orders based on estimated cost and timing**
  This is carried out.
- **Help establish job priorities**
  This is discussed in meetings.

- **Approve the tentative weekly plan presented by maintenance**
  This is carried out. Operations are as earlier mentioned heavily involved in the PM programme.
- **Participate in the weekly scheduling meeting and approve (or modify) the schedule recommended by maintenance**
  This is carried out.
- **Make equipment available according to the approved schedule**
  This is works generally well. However, if components are needed by customers urgently, the current machine has to keep running and it will not be available for PM service until later.
- **Adjust the availability of equipment to better meet the schedule**
  This is not the case. Operations have to follow the demands of the customer. As mentioned earlier, maintenance is a service for operations. It is not the other way round.

4.3 Cost Comparison

To get an impression of whether costs are high or low in companies generally, it can be interesting to compare financial data with similar companies in similar businesses. In table 4.3.1 below, a selection of injection moulding companies in the UK are listed presenting their maintenance costs compared to the overall turnover in 2005. (Ref. phone conversations with respective financial departments)

	Ecomold Ltd	Stadium Plastics	Harold Fisher Plastics	Denroy Plastics	Bolton Plastic Components
Maintenance costs *	£843,000	£345,000	£15,000	£60,000	£415,000
Turnover	£26,676,000	£21,800,000	£1,500,000	£5,000,000	£10,965,000
Share of maintenance	**3.16%**	**1.58%**	**1.00%**	**1.20%**	**3.78%**

Table 4.3.1: Cost comparison * including wages

Table 4.3.2 on the next page shows this comparison more clearly. With costs compared to the yearly turnover, a share of 3.16% is spent on maintenance within the Ecomold - Dunstable.

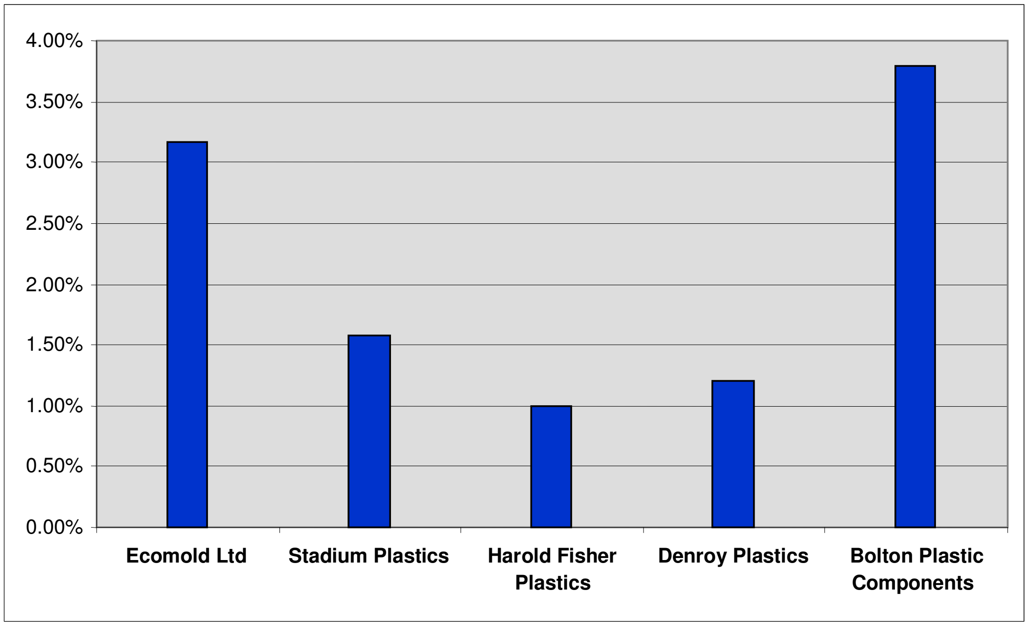

Figure 4.3.2: Cost comparison graph

Cost control

Maintenance costs are forecasted against production targets relative to time periods: monthly, annually, and so forth. This budgeting process establishes expectations against which actual expenditures are compared. With such a yardstick, performance is measured by comparing man-hours used, labour cost accrued, material cost accumulated, and total costs committed. The focus of these costs is equipment, buildings, or facilities maintained, activities performed, or jobs completed. Maintenance controls costs primarily by the effective use of labour. They can influence costs indirectly by encouraging production to operate equipment correctly. The overall cost control effort should include adequate preventive maintenance, emphasis on planned work, and use of cost-related information to help anticipate the need to prepare for and plan major work. See appendix 7 for an overview of costs.

Cost reduction

Maintenance can contribute to reducing product cost through a continuous effort of cost reduction in maintenance operations. Cost reduction in maintenance can be obtained by applying engineering method approaches. These approaches study how the work is being performed with the aim of developing a better way to perform maintenance. Engineering methods have well-defined steps for examining the maintenance work in order to simplify and eliminate unnecessary steps. This reduction and simplification of work results in cost savings. In effort aimed at reducing costs, the following should be considered.

- Alternative material and spare parts
- Alternative method for inspection and overhaul
- Alternative equipment and tools
- Alternative procedures for planning and scheduling
- Alternative job time standards

CHAPTER 5 – FEEDBACK SYSTEM

5.1 Computerised Maintenance Management Systems

The objective of maintenance organisations is to maximise uptime in the most cost-effective manner. To accomplish this objective, the following strategies must be clearly specified:

- Effective maintenance strategies derived from equipment condition and history
- Efficient techniques for planning and scheduling of work orders and utilisation of resources
- Monitoring of maintenance activities, data collection, and performance reporting to support continuous improvement

These three activities require information about equipment, workers, work orders, jobs, job standards, production schedules, and the nature of operations in the organisation. The amount of information that is collected, processed, and used for decision making is overwhelming, thus necessitating a systematic approach to information management. In addition, the complexity and the uncertainties involved in the process of maintenance and engineering and the amount of information handled in a typical maintenance system require computer support. Appropriate computer support provides the means for quick and timely response.

A computerised maintenance management system (CMMS) is basically an information system adapted to serve maintenance. CMMS aids in the process of data collection, recording, storing, updating, processing, communicating, and forecasting. It is essential for planning, scheduling, and controlling the maintenance activities. Through effective reporting, a CMMS can provide maintenance managers and engineers with the information needed for sound decision making to control and improve the maintenance process. Most organisations today have some sort of computerised maintenance support but may have failed to reap the full benefits of a CMMS for the following reasons:

- In many cases, the system does not meet the maintenance requirements
- The system is not user friendly
- Maintenance planners and engineers are not well trained in using the CMMS

- CMMS reports are not used for maintenance improvement

In the process of developing an in-house system, or choosing one from the hundreds of available commercial packages, the preceding items must be addressed carefully.

5.1.1 Overview

The success of a CMMS can be measured by its ability to support the maintenance process. Two important elements are essential for an effective CMMS:

- Its ability to support the main activities in the maintenance process
- The ability of the software and hardware configuration in terms of its reliability, ease of use, quality of information, and timely processing

A CMMS can be centralised in small organisations or completely decentralised and distributed in large organisations. It can run on mainframes, microcomputers, workstations, and personal computers. In addition, it can be a standalone system or part of a network in a client-server environment. A typical local-area network (LAN) may have several remotely located terminals, with perhaps 15 or more users and several printers. The software can be menu driven or window based. A typical CMMS is linked to inventory, payroll, purchasing, and accounting. Experience has shown that the system reliability, timeliness, and use enhance the utilisation of a CMMS and increase its benefits to the organisation.

In terms of support to the maintenance process, a CMMS usually includes the following functions:

- Equipment identification and bill of material
- Preventive maintenance
- Work order management
- Planning and scheduling
- Inventory control and purchasing
- Labour and job standards
- Equipment history
- Costs and budgets
- Performance reports
- Quality reports

In the design process of a CMMS, one or more of the preceding functions are usually grouped into one module.

5.2 Feedback System at Ecomold Ltd

As mentioned earlier, the current maintenance services are requested and reported with the use of the “Engineering Work Request” sheet attached in appendix 5. Using such a manual system for planning, requesting and reporting maintenance work has made it difficult to get a useful overview of the work record. Designing and implementing a feedback record system which will replace the manual Engineering Work Request sheet and which in addition displays relevant data such as costs and so on, makes it much easier for the maintenance manager, and others, to look back at work done on current machines and robots and see the actual costs of the work and parts needed. This feedback record system will therefore provide the relevant record data needed to make it easier to plan future similar jobs and enable staff to look back in time and see if a service really was *useful*.

5.2.1 System Requirements and Functions

The requirements of the new feedback record system are as follows:

- It must be designed for both *planned* and *unplanned* work
- The user requesting engineering work fills in a form similar to the old manual “Engineering Work Request” sheet and chooses the current machine or robot in the plant.
- The form includes both machine and robot work
- The data entered in the “Engineering Work Request” form is stored under the current machine or robot in a table displaying all machinery and displaying all planned/unplanned work for each machine/robot

5.2.2 Feedback System Results

5.2.2.1 Software and Design

The software used to design the feedback system was Microsoft Access. This application is a good alternative when it comes to storing databases such as lists of moulding machines and robots at Ecomold. It easily allows the user to generate and store lists and enter necessary data to the current machine or robot. It also has a good user interface when it comes to designing forms. The chosen form for display in this project was to use Microsoft Internet Explorer as the display application. This way, the user will only be presented with the necessary and relevant information needed and it gives a clearly set out and well arranged look and design.

5.2.2.2 Engineering Work Request

As shown in figure 5.2.1 on the next page, the Engineering Work Request display represents many of the same fields as on the manual Engineering Request sheet attached in appendix 5. New, is that certain fields have been left out because they were unnecessary, or they have been added/combined with other similar fields.

5.2.4 Maintenance Work Record

The Maintenance Work Record shown in figure 5.2.2 on page 53, as opposed to the Engineering Work Request, is the actual feedback programme itself. The user selects the current machine ID and necessary data such as type, serial number, location, year of manufacture, and data regarding any robot attached to the machine is displayed.

Next, when the user has selected the current machine or robot he/she will find all the records of maintenance work registered in the Engineering Work Request. All the fields included, the data entered are displayed, allowing the user to look back at work done, and take advantage of this information for future decision making.

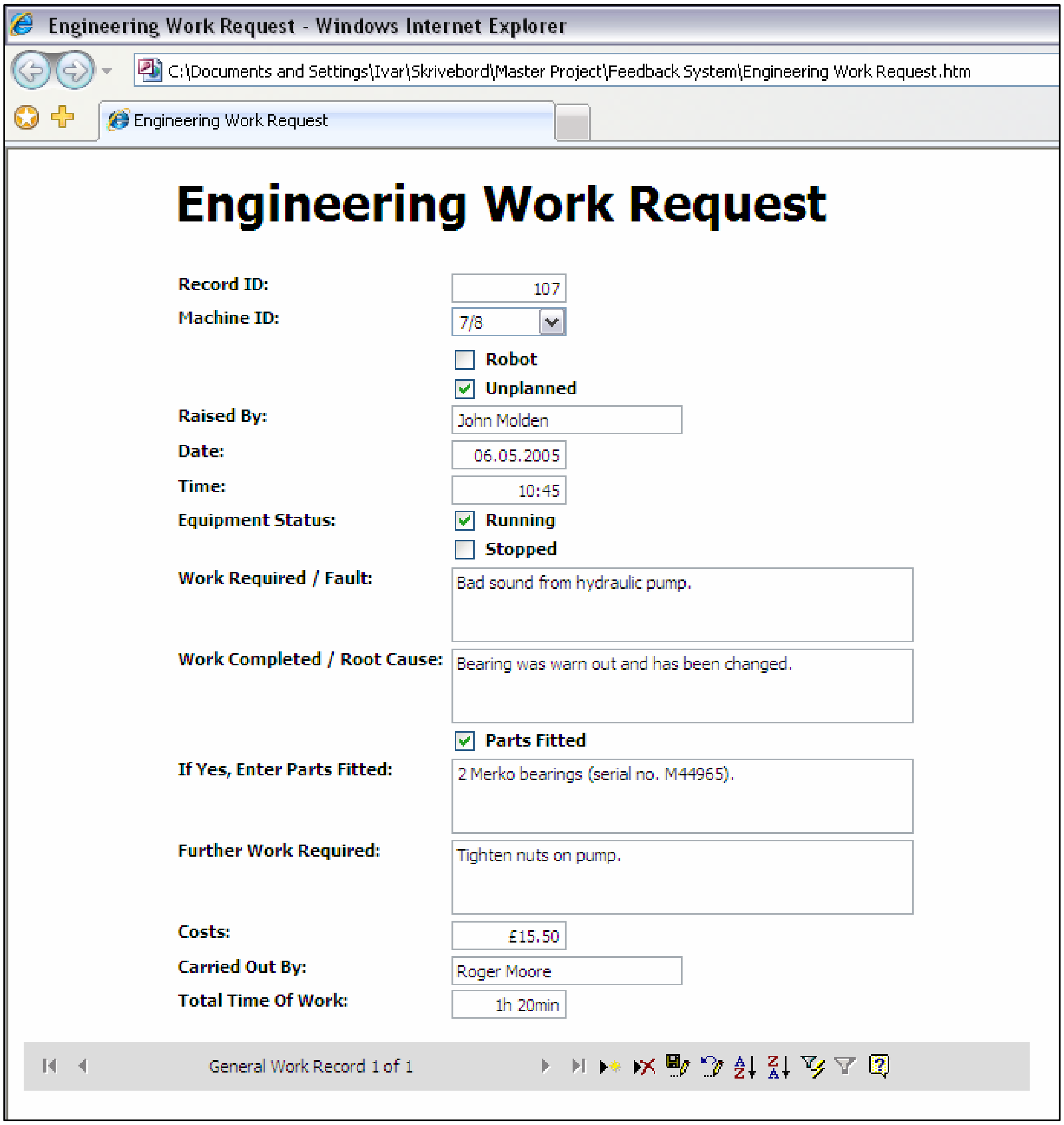

Figure 5.2.1: Engineering Work Request

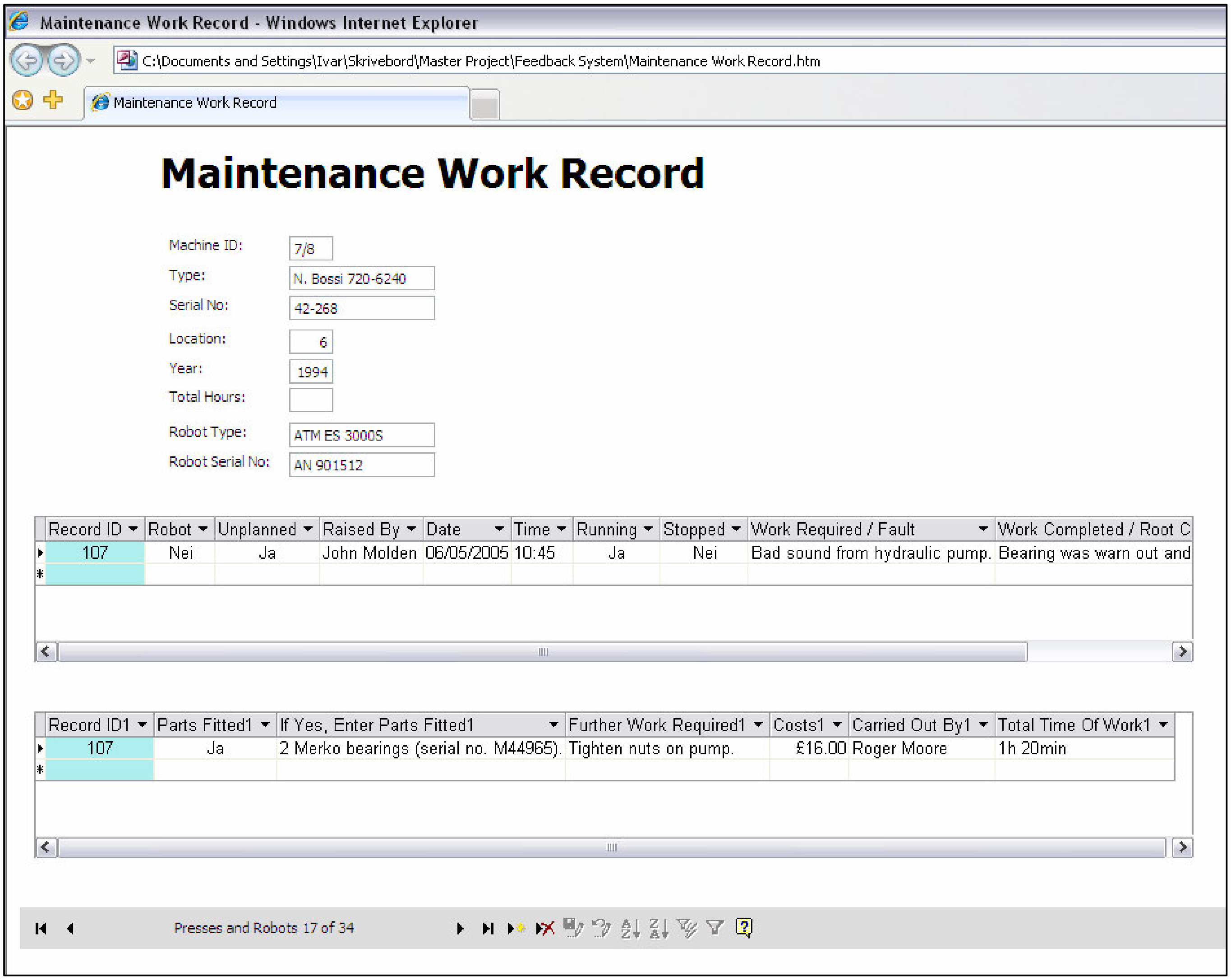

Figure 5.2.2: Maintenance Work Record

CHAPTER 6 – CONCLUSIONS

This evaluation of the maintenance function within Ecomold Ltd has identified both weaknesses which have the potential for improvements, *and* strengths of current maintenance routines.

In general, the optimal maintenance strategy is partly having established a quality maintenance programme which is used effectively. Many potentially effective maintenance programmes are rendered ineffective only because they are forced to operate in an environment where the programme can be ignored. To avoid this, a clear objective for maintenance must be established and policies prescribing how maintenance should be performed must be provided. Based on literature guidance, maintenance must define its programme so that all appropriate plant personnel can perform it effectively, use its services properly, and support it conscientiously.

The current maintenance routines within the Ecomold organisation perform well on main areas such as; timing of PM services, programme safety, PM programme intention fulfilment and clear common goals, prioritising, informing operations of issues, and care for hard-run equipment.

Considered improvements are areas that deal with; cooperation between maintenance and operators, the current manual work record system, plant-attitude towards maintenance, attainment of efficiency without imposing restraints, lack of policies within maintenance procedures, time for planning, and pre-PM actions by operations. See chapter 7 for further recommendations.

The new feedback system (which has been designed and will be implemented) for all planned and unplanned maintenance services, provides relevant feedback information to help prevention and solving of future issues. It includes all the relevant requirements desired by the company and will hopefully provide the department with useful help for easier decision making in the future.

CHAPTER 7 – FURTHER RECOMMENDATIONS

Based on the performance assessment presented in chapter 4, it is first of all recommended that a brief pre-PM action plan for operators is worked out and implemented. This will further help in sparing equipment life time and to a certain extent also further prevent equipment breakdowns.

Next, it is recommended that clear policies for work procedures are established. By doing this, the maintenance crew will have clear guidelines in what to do and work more efficiently. This will most likely also deal with the issue of achieving efficiencies without having to impose restraints.

Finally, as a result of the above, the number of equipment breakdowns will hopefully decline, and the maintenance manager will have more time for planning PM services, planning other future actions, and carrying out maintenance performance measurements to ensure continuously maximum maintenance efficiency.

CHAPTER 8 – REFLECTIONS ON THE RESEARCH

In general, having had the opportunity to carry out this master project in a company such as Ecomold Ltd abroad, has in all respects been very instructive and exciting.
In addition, the process of learning a new area such as the field of maintenance, comparing it with real-life routines, and having to design a feedback system with software which I have never used before, has given me great challenges and I find these experiences very valuable when entering the working life.

If I was to do this whole project again there are a few matters I would have done differently:

- I feel that a thorough assessment, including technical measurements of costs and routines, need much more time than 4 months which has been the available time carrying out this master project. With more time, one would be able to measure and not least *compare* different approaches and ideas for improvements, and after a number of series, assess the optimal solution based on the research.
- The selection of literature material may to a certain degree be a bit narrow compared to the ideal academic approach of written work. I think a more thorough comparison of different literature from books and articles could have given me an even better basis i.e. of comparing and measuring the maintenance function within Ecomold Ltd with the literature applied. Accordingly, the validity of the whole evaluation would have been much stronger.

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Appendixes

APPENDIX 1

Machine ID	Type	Serial No	Location	Year	Robot Type	Robot Serial No
14/1	N. Bossi V1400	64-107	8	1998	W450	060
20/1	Husky E2000	97098	8	1997		
3/3	Krauss Maffei	251151	8	1988	W430	066
8/2	N. Bossi V830	57-126	8	1997	W440	148
8/3	N. Bossi V830	57-127	8	1997	W440	149
8K-1	Battenfeld	49854	8	1994	W330	785
8K-2	Engel	32679	8	1998	W440	164
8K-3	Engel	32680	8	1998	W440	163
8K-4	Engel	32678	8	1997	W440	162
10/5	N. Bossi 1000-9800	44-151	6	1992	ATM ES 3000S	AN 901511
10/6	N. Bossi V980	58-123	6	1998	W450	092
13/1	Demag NC III	83-0030	6	1988	ATM ES 3000	AN 901158
13/2	Demag	832-0040	6	1995	W500	036
5/2	Demag	862-1065	6	1998	W433	128
7/12	N. Bossi 720	42-299	6	1995	W641	161
7/7	N. Bossi 720-6240	42-225	6	1991		
7/8	N. Bossi 720-6240	42-268	6	1994	ATM ES 3000S	AN 901512
7/9	N. Bossi 720-6240	1435-00	6	1994		
8/1	N. Bossi 800	57-115	6	1997	W641	160
18/3	Demag NC III	834-0014	4	1988	DR50	012
18/6	Demag NC III	834-0021	4	1992	DR50	010
18/7	Demag NC III	834-0022	4	1992		
22/3	Demag NC III	838-0002	4	1990		
27/1	Demag NC III	8350011	4	1988	W500	590
27/2	Husky E2700 RS155	97100	4	1998	W510	027
10/7	N. Bossi V980	58-173	3	2001	W643	021
10/8	N. Bossi V980	58-174	3	2001	W643	020
12/1	Demag NC III	832-0023	3	1986		
3/1	N. Bossi	54-397	3	1997		
7/10	N. Bossi	42-304	3	1995	W641	275
7/11	N. Bossi	42-302	3	1995	W643	015
10/4	N. Bossi 1000-9800	44-121	2	1988	W633	232
14/2	N. Bossi V1400	64-111	2	1999	W450	122
18/4	Demag	834-0023	2	1993	W500	033

APPENDIX 2

Task ↓ Week →	Feb 6	Feb 7	Feb 8	Mar 9	Mar 10	Mar 11	Mar 12	Mar 13	Apr 14	Apr 15	Apr 16	Apr 17	May 18	May 19	May 20	May 21
Work out project time plan and familiarise with machinery and plant	■															
Research on maintenance costs within general moulding industries		■														
Research on general maintenance theory		■	■													
Carry out survey on maintenance routines onsite (questionnaire)			■	■												
Analysis of survey and data recorded					■											
Comparison of current maintenance routines with theoretically optimal maintenance routines						■										
Analysis of previous systems							■			Easter holiday break						
Research to new approaches							■	■								
Assessment of data collection									■							
Development and design of feedback system											■	■				
Train team, introduce new system and present findings													■			
Report writing														■	■	
Project hand-in																■

APPENDIX 3

Maintenance Evaluation Questionnaire

The Maintenance Function

Quality performance by the Maintenance department helps assure the Ecomold plant profitability. The preventive maintenance (PM) programme should successfully extend equipment life and avoid premature failures through timely inspection, testing, lubrication, cleaning, adjustment, and minor component replacements. As a result, there should be fewer emergency jobs and more work should be able to be planned. As the planned work is performed, maintenance personnel will work more productively and the results will have lasting quality.

Objective

With relations to a student project carried out onsite (*Performance Measurement of the Maintenance function)*, it is desirable to identify how well the maintenance routines on moulding and robot machinery within the Ecomold plant are performing.
It is important that you consider this questionnaire as an attempt to improve your environment, both the maintenance routines and the organisation as a whole, and not a critic measure of your personal performances, skills or knowledge.

Responsibility Area

The factors over which you have no control, i.e. machinery being pushed beyond maintenance due dates by operators pursuing unrealistic targets, is not within your responsibility area, nor either a factor which should influence your answers in this questionnaire.

Ecomold – Dunstable

1st March, 2006

Please rate the organisation, execution, and effectiveness of preventive maintenance by comparing the following standards with the performance of your maintenance department, based on your personal knowledge.
Rate *1* (lowest) to *7* (highest) if you have personal knowledge on the current standard. If you feel that your job does not require that you evaluate one of the standards, please tick the *"don't know"* alternative.

THE PROGRAMME

1. There is an effective overall preventive maintenance (PM) programme.

1	2	3	4	5	6	7	Don't know

2. The PM programme is oriented toward uncovering deficiencies before equipment fails.

1	2	3	4	5	6	7	Don't know

3. There is evidence that the PM programme has reduced the amount of emergency work.

1	2	3	4	5	6	7	Don't know

4. As the result of the PM programme, more work is being planned.

1	2	3	4	5	6	7	Don't know

5. PM services are verified for quality and adherence to the schedule.

1	2	3	4	5	6	7	Don't know

6. New equipment is added to the PM programme promptly.

1	2	3	4	5	6	7	Don't know

7. **The PM programme is reviewed periodically and updated to reflect changing conditions.**

1	2	3	4	5	6	7	Don't know

8. **Appropriate non-destructive testing techniques such as vibration-analysis and infrared testing have been identified and, as required, integrated into the PM programme.**

1	2	3	4	5	6	7	Don't know

9. **Each PM Service has a standardised checklist which explains how and when the service is to be performed.**

1	2	3	4	5	6	7	Don't know

10. **Each PM action is identified by a code or number to aid in scheduling, control, and reporting.**

1	2	3	4	5	6	7	Don't know

11. **Extensive repair actions during the conduct of PM services, especially inspections, are avoided.**

1	2	3	4	5	6	7	Don't know

12. **The timing of PM services is carefully regulated according to fixed time intervals or accumulated operating hours.**

1	2	3	4	5	6	7	Don't know

13. **PM services for individual units of fixed equipment are linked together in routes to avoid unnecessary travel time or backtracking.**

1	2	3	4	5	6	7	Don't know

THE ORGANISATION

14. The manpower required for each PM Service and for the entire PM programme is known.

1	2	3	4	5	6	7	Don't know

15. Maintenance personnel conduct PM services effectively.

1	2	3	4	5	6	7	Don't know

16. Maintenance supervisors ensure that PM services are performed effectively and on time.

1	2	3	4	5	6	7	Don't know

THE ENVIRONMENT

17. Plant Management understands and strongly supports PM.

1	2	3	4	5	6	7	Don't know

18. The PM programme emphasises safety.

1	2	3	4	5	6	7	Don't know

19. The PM programme emphasises the preservation of assets.

1	2	3	4	5	6	7	Don't know

20. The PM programme has been explained to operating personnel to enable them to cooperate and use its services effectively.

1	2	3	4	5	6	7	Don't know

21. **Operating personnel cooperate with the PM programme and perform simple, routine PM related tasks to help ensure dependable operation of equipment.**

1	2	3	4	5	6	7	Don't know

22. **Individual operators and maintenance workers cooperate in the conduct of PM services.**

1	2	3	4	5	6	7	Don't know

EXPERIENCE

23. **Please tick the appropriate alternative that matches your title.**

	Manager
	Engineer
	Apprentice
	Other (please state)

24. **How many years have you been employed in the Maintenance department?**

0 - 1	2 - 5	6 - 10	11 - 20	21 - 30

Thank you very much for your time filling out this questionnaire. Hopefully, in the future your contribution to this survey will further improve the performance of the maintenance function and also help to assure the Ecomold plant profitability.

APPENDIX 4

2-5

Category / Question no.	Result
Programme	
1	***3.00***
2	***4.00***
3	***3.00***
4	***5.00***
5	***2.67***
6	***2.50***
7	***3.33***
8	***2.00***
9	***4.00***
10	***3.00***
11	***3.33***
12	***5.00***
13	***3.00***
Organisation	
14	***3.50***
15	***4.33***
16	***3.33***
Environment	
17	***5.50***
18	***5.33***
19	***4.67***
20	***4.33***
21	***4.00***
22	***5.00***

6-10

Category / Question no.	Result
Programme	
1	***2.00***
2	***4.00***
3	***1.50***
4	***2.00***
5	***4.00***
6	
7	***1.00***
8	***6.00***
9	***3.50***
10	***1.00***
11	***5.00***
12	***4.50***
13	***2.00***
Organisation	
14	***4.00***
15	***4.00***
16	***6.00***
Environment	
17	***1.00***
18	***5.00***
19	***5.00***
20	***1.00***
21	***1.00***
22	***1.00***

21-30

Category / Question no.	Result
Programme	
1	***5.00***
2	***7.00***
3	
4	***3.00***
5	***5.00***
6	
7	***1.00***
8	***6.00***
9	***7.00***
10	***2.00***
11	***5.00***
12	***7.00***
13	
Organisation	
14	***5.00***
15	***5.00***
16	***3.00***
Environment	
17	
18	***5.00***
19	***4.00***
20	***1.00***
21	
22	***1.00***

Total

Category / Question no.	Result
Programme	
1	***3.33***
2	***5.00***
3	***2.25***
4	***3.33***
5	***3.89***
6	***2.50***
7	***1.78***
8	***4.67***
9	***4.83***
10	***2.00***
11	***4.44***
12	***5.50***
13	***2.50***
Organisation	
14	***4.17***
15	***4.44***
16	***4.11***
Environment	
17	***3.25***
18	***5.11***
19	***4.56***
20	***2.11***
21	***2.50***
22	***2.33***

APPENDIX 5

ENGINEERING WORK REQUEST

DESCRIPTION / PRESS / TOOL NO. OF EQUIPMENT (CAPITALS)	LOCATION: (CAPITALS)	MODULE: (CAPITALS)
RAISED BY: (CAPITALS)	DATE:	TIME: (24 Hour)
EQUIPMENT STATUS:	STOPPED / STILL RUNNING	

WORK REQUIRED / FAULT

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

WORK COMPLETED ☐ UNPLANNED ☐ PLANNED ☐ OTHER (ex 5C'S)

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

CAUSE OF FAULT (if known)

……………………………………………………………………………………………………

……………………………………………………………………………………………………

PARTS FITTED ☐ YES ☐ NO If YES, state parts fitted …………………………………………… …………………………………………… PARTS REQUIRED ☐ YES ☐ NO If YES, state parts required …………………………………………… ……………………………………………	FURTHER WORK REQUIRED …………………………………………… …………………………………………… …………………………………………… …………………………………………… …………………………………………… ……………………………………………

WORK CARRIED OUT BY:

Print Name …………………….. Signature: ……………………………………

TIME ON: (24 hour)	TIME OFF: (24 hour)	DATE:

APPENDIX 6

Ecomold – Dunstable

Robot Service Report

Date:	
Machine No.:	
Robot Type:	
Serial No.:	

Checks Completed

Bearings – wear / condition	☐
Cables – wear / condition	☐
Motors and gearboxes – wear / backlash	☐
Belt tension and condition (or chains)	☐
Pulley / belt alignment	☐
Pneumatics (also vacuum / grippers) – pressure and condition	☐
Racks and linear runners	☐
Security and adjustment of proximity switches and cams	☐
Security of platen adaptor / robot	☐
Gripper integrity and security to headstock	☐
Motor brake gaps / operation	☐
General security of all mechanical components	☐
General security and function of all electrical components – relays etc.	☐
Encoder condition and zero point adjustment	☐
S5 / S6 hardware roller safety switches – operation / condition	☐

Recommendations:

____

____

____

____

____

____

____

____

Engineer's Signature______________________________

APPENDIX 7

ecomold limited - Dunstable **Period 03 - March 2006**

Weekly Operations Sheet

Subject		Week 9 (1)	10 (2)	11 (3)	12 (4)	13 (5)	Cumulative	Monthly Forecast	Monthly Plan
Sales - £'000									
BU 1	Forecast	223	224	224	224	224	1,119	1,119	1,187
	Actual	242	232	260	262	321	1,317		
BU 2	Forecast	225	225	225	225	225	1,125	1,125	1,055
	Actual	225	258	263	250	269	1,265		
Total	Forecast	448	449	449	449	449	2,244	2,244	2,242
	Actual	467	490	523	512	590	2,582		
	% Achieved	104.2	109.1	116.5	114.0	131.4	115.1		
Operator Labour Hours									
Hours	Forecast	4,057	4,112	4,282	4,521	4,212	21,184		
	Actual (Inc Temps)	5,561	5,687	6,132	6,064	5,910	29,353		
	% Efficiency	73%	72%	70%	75%	71%	72%		
Direct Labour Cost									
	Forecast (15.4%)	68,416	69,146	69,146	69,146	69,146	345,000	345,000	340,000
	Adjusted Labour	71,318	75,460	80,542	78,848	90,860	397,028		
	Actual - Permanent	60,522	56,142	61,241	61,669	58,967	298,541		
	Actual - Temps	11,072	13,232	14,968	14,984	15,808	70,064		
	Total	71,594	69,374	76,209	76,653	74,775	368,605		
	Variance	276	-6,086	-4,333	-2,195	-16,085	-28,423		
	% Spend	0%	-9%	-6%	-3%	-22%	-8%		
% Overtime (Operators)		4.5	1.3	6.3	7.6	8.1	5.6		
% Overtime (Setters)		25.2	20.6	26.8	22.9	18.4	22.8		
% Overtime (Temps)		0.0	0.5	2.8	1.3	7.3	2.4		
Labour - Engineering (540)									
Hours	Forecast	439	439	439	439	439	2,195		
	Actual	509	366	403	499	518	2,296		
Cost	Forecast	6,700	6,700	6,700	6,700	6,700	33,500	33,500	29,900
	Actual	7,811	5,310	6,032	9,199	7,747	36,099		
% Overtime		24.6	15.8	22.6	17.1	19.8	20.0		
Labour - Stores/Warehouse (570)									
Hours	Forecast	1,197	1,197	1,197	1,197	1,197	5,985		
	Actual	1,170	1,221	1,244	1,232	1,227	6,094		
Cost	Forecast	13,800	13,800	13,800	13,800	13,800	69,000	69,000	64,800
	Actual	12,773	13,719	13,796	17,166	13,861	71,315		
% Overtime		6.2	5.9	8.1	15.2	11.1	9.3		
Site Overtime %		7.7	4.9	8.4	10.1	10.3	8.3		
Absence									
	Directs	4.4	4.5	4.3	7.0	7.7	5.6		
	Indirects	1.2	2.0	1.0	2.6	3.8	2.1		
L&B Maintenance Reqs Raised									
	Forecast	2.0	2.0	2.0	1.9	1.9	9.8	9,800	9,800
	Actual	3.3	2.5	0.1	6.9	2.5	15.3		
M/C Maintenance Reqs Raised									
	Forecast	2.2	2.2	2.3	2.3	2.3	11.3	11,300	18,600
	Actual	7.0	6.7	1.5	1.1	7.7	24.0		
Toolroom Maint Reqs Raised									
	Forecast	1.1	1.1	1.0	1.0	1.0	5.2	5,200	5,200
	Actual	2.3	3.9	1.0	1.5	1.8	10.5		