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SEMINAR PENCAPAIAN PENYELIDIKAN UTeM (REACH '07)

Towards R&D Excellence

18-20 Januari 2008

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UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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[illegible] & Communication Technology

Computerized Maintenance Management System for Food Processing Industries

M.A Burhanuddin, A.R. Ahmad, M.I. Desa, M.Y. Zeratul, R. Sazalinsyah

Abstract- **Breakdown define as total amount of time the equipment would normally be out of operation from the moment it fails until the moment it is fully repaired and operational. Depending on these nature of the breakdown, some maintenance activities may take place before the service is restored into their normal operation. Downtimes of productions unit may result capacity loss, poor product quality, customer dissatisfaction and environmental impact. In fact, these downtimes can be forecasted and managed more effectively if an organization takes preemptive measures using artificial intelligence techniques such as data mining, neural networks, genetic algorithm etc. This will provide good estimate to predict next failures. The proposed research project reveals the risk factors that either delay or accelerate downtimes.** ***It also demonstrates the extent of such delay,*** **attributable to specific risk factors. Once risk factors are detected, the maintenance managers are aware of the starting and finishing points for each maintenance job due to their prior knowledge about the potential barriers or covariates. We develop a prototype of the Computerized Maintenance Management System (CMMS) as a tool for maintenance management team, which consist of work order, preventive maintenance, corrective maintenance and inventory control system.**

Keywords- Computerized Maintenance Management System, preventive maintenance, corrective maintenance, decision support system

1. INTRODUCTION

In general, machine downtime can be defined as a total amount of time the equipment failed. Once faults are detected either in the requirements, in the design or else in the code, they require attention, and the corrective maintenance process is initiated until the moment the machine is fully recovered and operational. The more faults or errors are found, then the more resources will be spent to repair. Here, repair is defined as to restore the interrupted service by replacing the parts or to sort out that are torn or broken.

Downtimes of machines in productions may result capacity loss, poor product quality, customer dissatisfaction and environmental impact. The most frequent questions asked during the breakdown is, how long the repair activities will take place? And yet, this is the most difficult question to answer by maintenance operation team. Unless, if the repairing measures can be formulated using mathematics preemptive measures or artificial intelligence techniques.

Currently, time based measurement concept is very important for customers and widely used for products, systems, processes and services which extended from various fields as an interdisciplinary concept. However, according to Mustafa(2002), there are still not sufficient studies made on the application of measurement in service processes as it always taken into consideration in a verbal sense and is not dealt with mathematically. He proposed output oriented management concept, which can be used to evaluate some maintenance performance index. Therefore, downtime can be forecasted and managed *more effectively if maintenance department takes mathematics preemptive* measures and embedded with artificial intelligence techniques such as neural networks, genetic algorithm *etc*. This will provide better estimate to predict troubleshooting time.

2. PROBLEM DEFINITION

The manufacturing users will obviously wish to minimize the downtime and fully utilize the machines or operation units along their lifetime. When the operation unit goes beyond the warranty period in production lines, the manufacturing maintenance department will have to pay all the cost of system failures, throughout the lifetime of the unit. In this case, time is considered as the cost as it is contract with the utilization of the resources.

We have visited few food processing companies in Malaysia and discovered that there are covariates or risk factors which directly impact on delay in either responding or repairing time intervals, whenever any service downgrades or complete failures of the machines. Quantitative measures based on the previous repair time intervals can reveal those risk factors. Once the previous repair time patterns are learned, the maintenance planners, supervisors and technicians can forecast for faster recovery plan from those repetitive failures. To achieve this objectives, all records on maintenance activities must be kept in proper for data mining purposes. The development of computerized maintenance management system is essential to solve the problem.

3. PROJECT OBJECTIVES

The objectives of the project are given as follows:

i) To design a prototype of the computerized maintenance management system (CMMS) for food processing industries;
ii) To develop user-friendly CMMS as a replacement to the existing manual forms system in maintenance department;
iii) To extend the use of the complex system failure analysis, suggested by Choy *et. al.*(1996) and Prasad *et. al.* (2002) to analyze troubleshooting time in the manufacturing lines;
iv) To help factory to produce automated reports and graphs from the system.

4. LITERATURE REVIEW

One of the top three highest spending elements of productions in most of the industries is the operating cost. The cost of maintenance operation is rising along with technology, in absolute terms as a proportion of total expenditure. Thus, achieving the low production cost is not only by studying the techniques, but also to decide which techniques are worthwhile to prioritize in the respective functional group in the organizations. Moubray(1997) highlighted some important points in maintenance:

i) Team work between maintenance crew and operators in the production floor;
ii) Decision support tools, such as reliability studies, failure modes and effects analysis;
iii) When any failures occurs, ability to redesign the equipment with a much greater emphasis on reliability or introducing backup and standby strategies; and
iv) Expert systems development, such as automatic condition monitoring capabilities and remote maintenance management control.

There are two publications, most closely related to our work: Labib(1998) and Bentley(1993). Then Labib(2004) develop world class CMMS by defining decision making grid as a control chart by itself in 2 dimensional matrix forms. The columns of the matrix show the 3 criterion of the downtime. While the rows of the matrix show another 3 criterion of the frequencies of the failures. A better maintenance model for quality management can be formed by handling both the rows and columns of the matrix respectively. The matrix offers an opportunity to decide what maintenance strategies is needed for decision making such as to practice fixed-time maintenance, condition-based maintenance or design-out maintenance. The matrix is also can be used to decide what maintenance concepts are useful for each defined cell of the matrix such as total productive maintenance (TPM) or reliability centered maintenance (RCM) approaches. The results can provide maintenance policies in the respective functional group in production lines to achieve their common goal by identifying risk factors. Water(2000) proposed some structures on risk factors for maintenance policy decision making, *i.e.* when to practice use-based maintenance, condition-based maintenance or failure-based maintenance.

Let us have a closer look on the interference [illegible] factors that might arise at a few of the [illegible] Figure1. Let us define symbols, *S1* is [illegible] regular repair, S2 is failed [illegible] operation, *S3* is failed unit [illegible] is failed unit is continued [illegible] failed unit is continued repair [illegible] failed unit will be attended to [illegible] team which perform regular [illegible] state *S1* and return it back to [illegible] without facing any problem. [illegible] experiences a transition to states [illegible] high possibility of a delay and [illegible] significant risk factors that exist [illegible] an event. These are [illegible] categories are the special cases [illegible] in our study. Risk factors may [illegible] either *S3*, or *S4* due to such [illegible] competency, experience, age or [illegible] the technicians. It also could be [illegible] characteristics of the machine such as [illegible] records of preventive maintenance. [illegible] other obstacles such as ordering delay [illegible] parts.

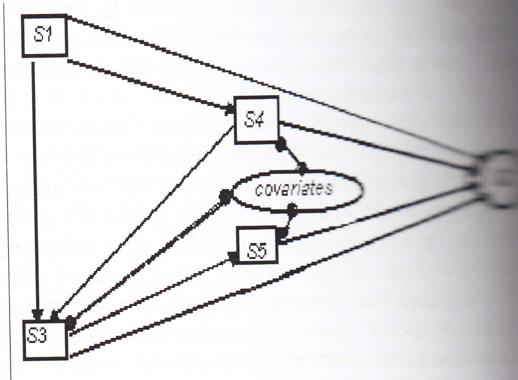

Figure 1: Failed Unit repairing state [illegible]

The system may be in one of the states [illegible] where the first letter of the symbol denotes [illegible] the unit and the second corresponds to the [illegible] state of the device. Repair data can be [illegible] patterns in a variety of ways to identify [illegible] sources of repeat problem recurrences. Overtime [illegible] emergency maintenance affects the cost of the [illegible] data about this can indicate the economic [illegible] benefits in improving the process.

Usually, a service provider sets the Standard [illegible] Agreement (*SLA*) within the organization on the [illegible] time for specific major components as a bench[illegible] goal in order to be a vendor of choice in a com[illegible] market. Figure 2 shows the progress of troubleshooting [illegible] repair represented by a line, *L1* which is Standard [illegible] Agreement. Let line, *L2* be a real case, *L3* as [illegible] achieving the target in real case, *L4* as missing the [illegible] and *G* is a goal or target.

For most of the cases, the technical staff [illegible] troubleshoot as shown by *L2* and update [illegible]

...entation accordingly but still meeting the goal, *G* ...ough line *L3*. The organization always sets the ...ndard maintenance procedure to follow in order to ...et the *SLA* at all times. However, there are always ...ecial cases where troubleshooting activities miss lead ...d causes a delay along line *L4*. At this stage, the delays ...e due to some risk factors or covariates as discussed in ...gure 1 above.

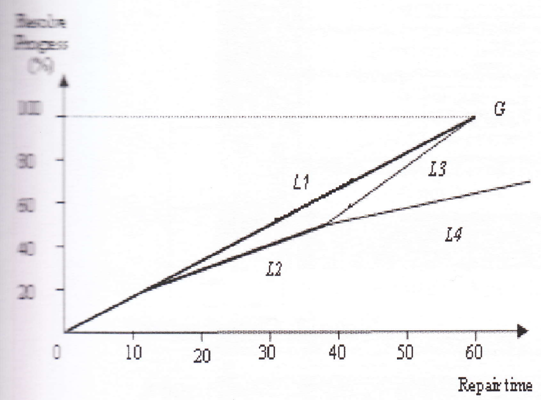

Figure 2: Achieving the Operational Target through Standard Level Agreement

In this research, CMMS is developed. Next, we should ...e able to extract and process the raw data using data ...ining techniques. We can identify those significant risk ...ctors and estimate repair time performance index by ...sing the mathematical approaches. Once the index ...btained, it will be used as an input or weightage in ...rtificial intelligence models such as neural networks. ...hen we are able to derive few important decision ...rategies and provide useful information to the ...aintenance management group.

. MEASURE OF MACHINES EFFICIENCY

Previous and ongoing works in maintenance modeling ...search have given us some ideas to formulate the ...tegrated maintenance activities in the production floors. ...nce most of the reliability, availability and failures of ...e machines are dependent on time, Bentley(1993) ...presented the repetitive failure patterns as shown in ...gure 3. He assumed that *N* individual machines placed ...operation are up and running. The times at which ...ilures, *f*, occur are recorded during a test time interval, ... Let the downtime, T_{Dj} be the total time that elapses ...etween the occurrence of the *j*th failure and the time the ...quipment back into normal operation. Let N_f be the ...mber of failures of the *N* device during the *T* interval.

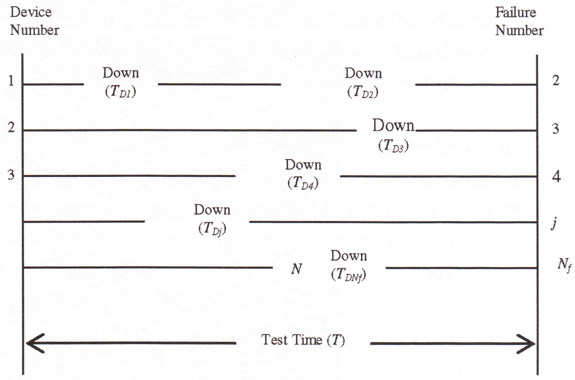

Figure 3: Repairable Items Failure Patterns (Bentley(1993))

Based on Figure 3, Bentley(1993) derived few measures and formulae as follows:

$$\text{Mean Downtime (MDT)} = \frac{1}{N_f}\sum_{j=1}^{j=N_f} T_{Dj}$$

$$\text{Total Up time} = NT - \sum_{j=1}^{j=N_f} T_{Dj}$$

$$\text{Mean Time Between Failures (MTBF)} = \frac{NT - N_f MDT}{N_f}$$

$$\text{Failure rate } (\lambda) = \frac{N_f}{NT - N_f MDT}$$

$$\text{Availability} = \frac{(N_f \times MTBF)}{(N_f \times MTBF) + (N_f \times MDT)}$$

$$\text{Unavailability} = \frac{(N_f \times MDT)}{(N_f \times MTBF) + (N_f \times MDT)}$$

The relationship between the concepts of reliability from MTBF, MDT, mean waiting time (MWT) and mean time to repair (MTTR) are given in Figure 4. The machine is reliable when their MTBF is higher. As contrast, the lower is better for MDT.

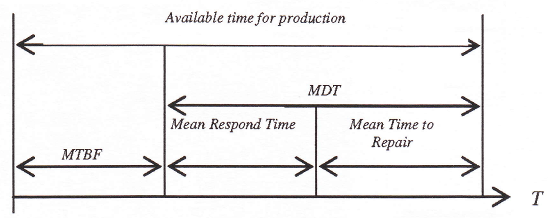

Figure 4: The relationship between MTBF, MDT, Mean Respond Time and Mean time to repair (MTTR)

As of our case study in the food processing company, we observed few main characteristics, that machines must operate, are given as follows:

i) Reliability: they must work for at least 10 hours per day, 6 days a week in a year. MTBF and MDT index can be used as reliability measures;
ii) Every machine may have different frequency of failures. Once failed, it has different downtime,

which includes waiting and repairing time; and

iii) Machines operate in a serial line to manufacture seven types of products in different volumes.

In order to quantify both, time and costs of maintenance, various maintenance models were introduced. However, most of the mathematical methods to decide the inspection intervals are too complicated to be resolved as 'ready to use' numerical solutions. Moreover, in the practical applications, the machinery plants must satisfy the required conditions of these theoretical models; which are not the case usually. And yet, in this paper we proposed an intelligent decision support model to define maintenance strategies for the specific machine in production plants.

6. Software Design For Food Processing Companies

Hierarchy Input Process Output design is shown in Figure 5.

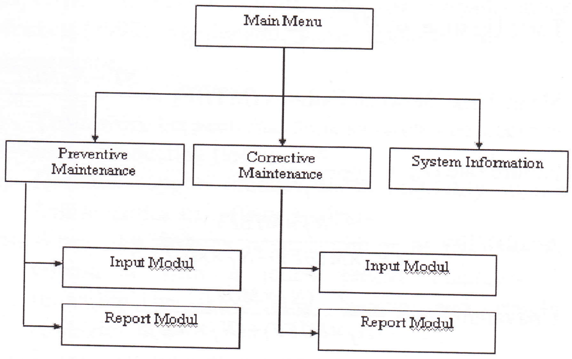

Figure 5: Main Modules

The entity relationship diagram for CMMS is shown in Figure 6.

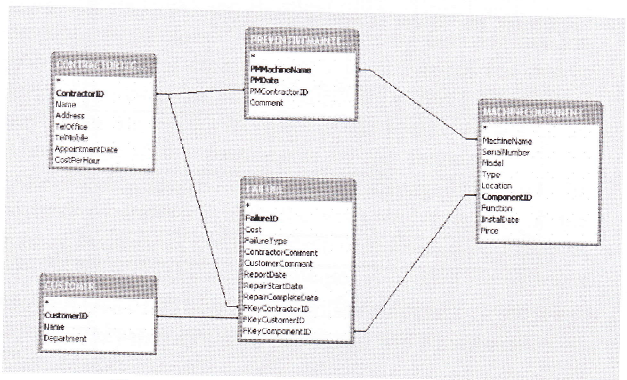

Figure 6: Entity relationship diagram

Class diagram is shown in Figure 7.

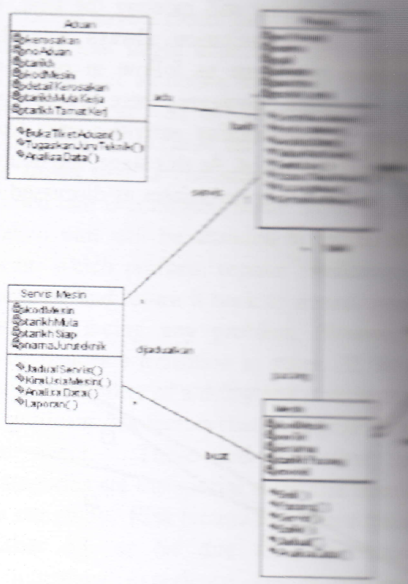

Figure 7: Class diagram

Use-case diagram is shown in Figure 8.

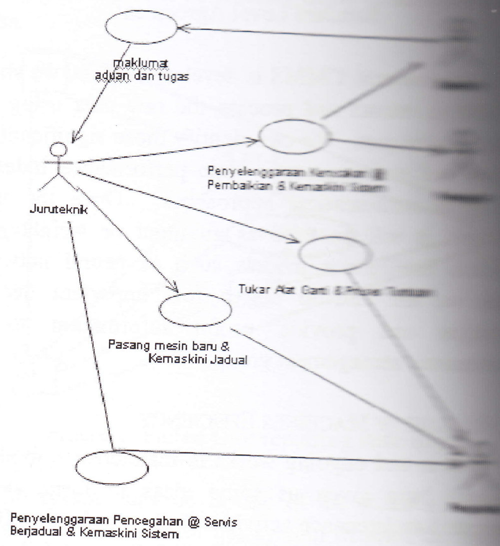

Figure 8: Use-case diagram

7. CMMS For Food Processing Small and Medium Industry: User Interface and Examples

As a case study, we have developed a CMMS prototype on current manual system for one of the food processing companies in Johor. Main Menu interface is shown in Figure 9. Corrective Maintenance Menu is shown in Figure 10 and Corrective Maintenance Input Menu is shown in Figure 11. Preventive Maintenance Menu is shown in Figure 12 and Preventive Maintenance Input Menu is shown in Figure 13.

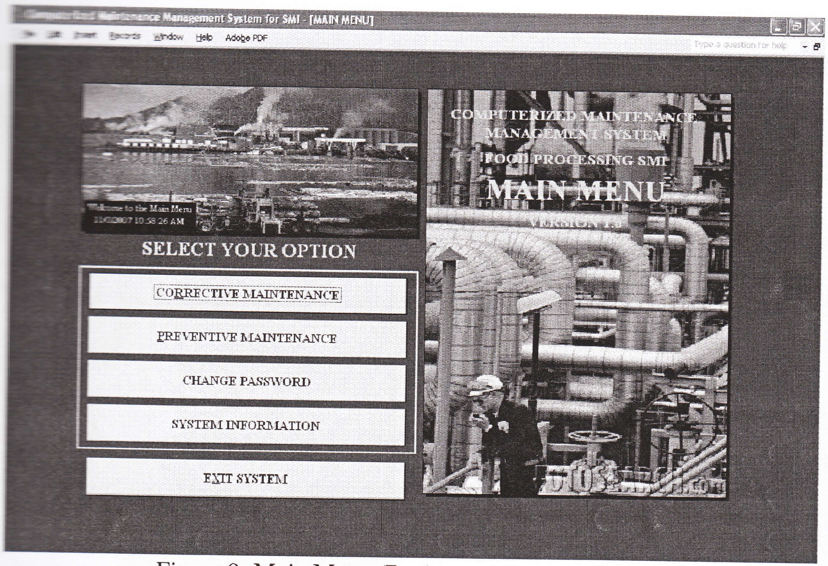

Figure 9: Main Menu (Burhanuddin *et. al.* (2007))

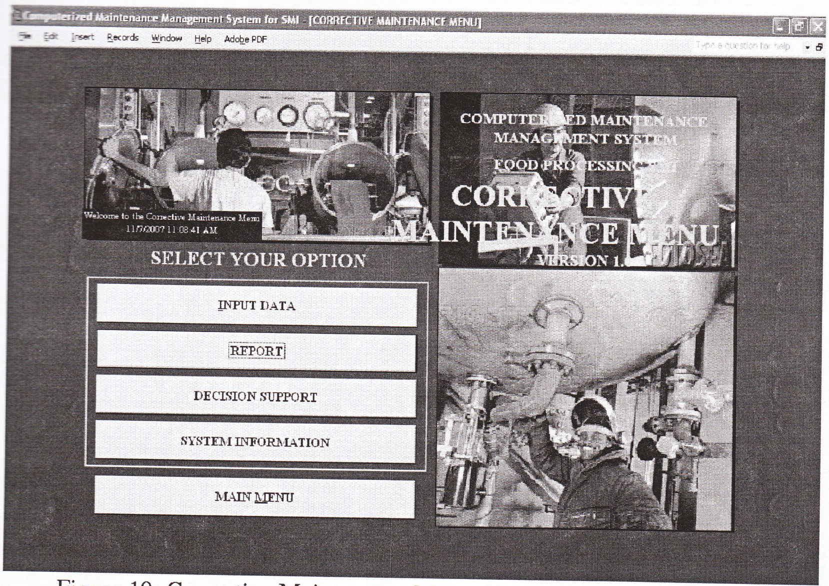

Figure 10: Corrective Maintenance Menu (Burhanuddin *et. al.* (2007))

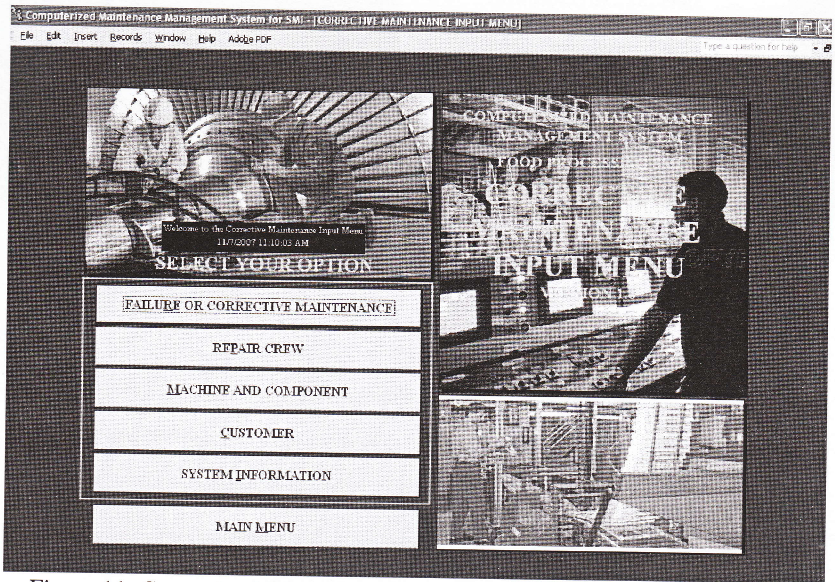

Figure 11: Corrective Maintenance Input Menu (Burhanuddin *et. al.* (2007))

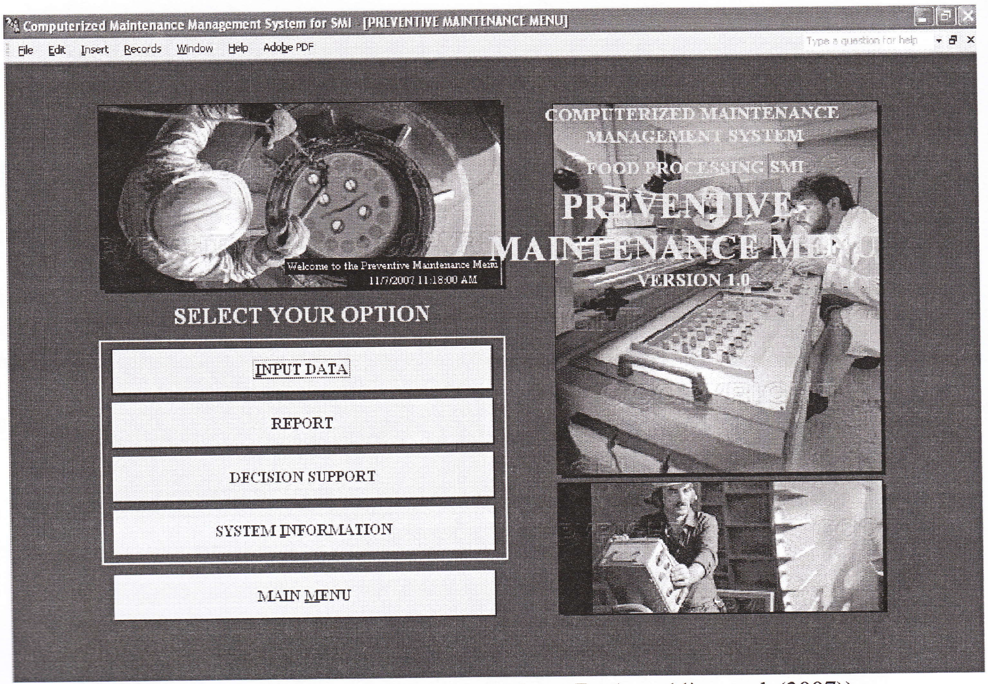

Figure 12: Preventive Maintenance Menu (Burhanuddin *et. al.* (2007))

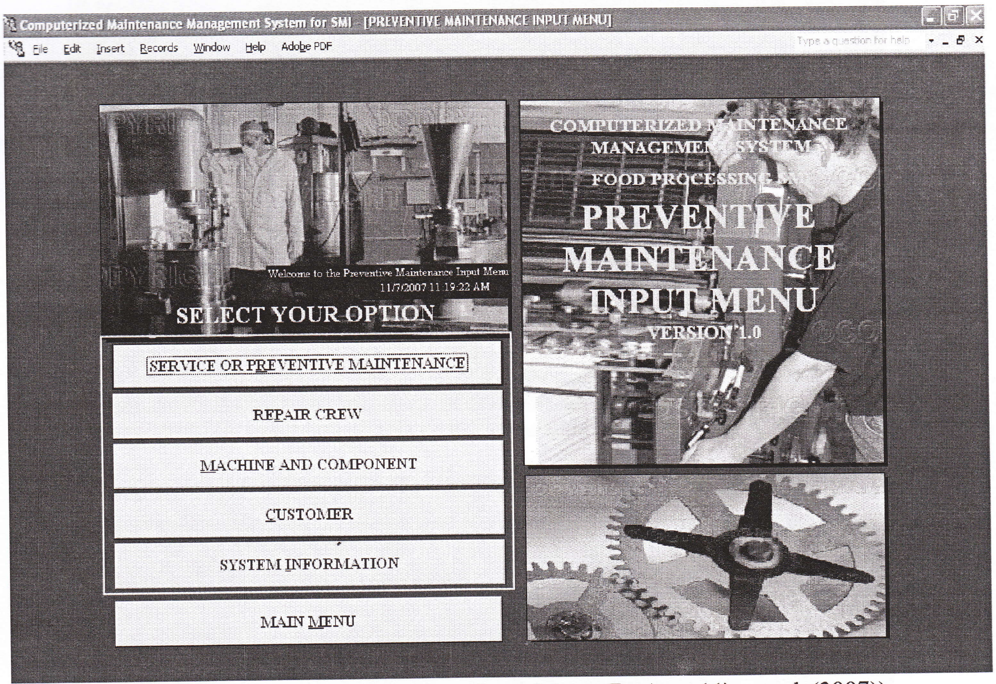

Figure 13: Preventive Maintenance Input Menu (Burhanuddin *et. al.* (2007))

8. CONCLUDING REMARKS

Food processing companies in Malaysia startup with smaller capitals, hence they are not able to upgrade the entire production lines as a whole. They always operate with limited number of machines to produce a few types of products. The machines operate with their own specific functions and always contribute to a dedicated mission in the production serial lines. They operate with the minimum number of maintenance staff. As far as maintenance is concerned, they will just follow maintenance guidelines provided by the machine's suppliers. Hence, they may either under or over maintain certain equipment in their production floor. Therefore, it is important for them to have a computerized maintenance management system (CMMS) in place to measure the machines and other maintenance resources. In this research project, we managed to design and develop a CMMS, which includes work order, preventive maintenance and corrective maintenance function.

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