Spare Parts Waste Management with The Addition of Modules on Spare Parts Management Function in Computerised Maintenance Management System

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Abstract- ***The efficient and sustainable management of waste parts has become a major concern in many modern industrial facilities. These facilities face challenges in controlling, managing, and minimising the waste generated during the routine turnover of spare parts. In an effort to address these issues, this research analyses spare part waste, develops criteria for spare part waste, and implements it into a Computerised Maintenance Management System (CMMS) to improve spare part waste management in industrial facilities. This research analyses spare part waste in a particular industrial sector, involves a survey of the existing spare part waste management process to design a CMMS along with adding modules and identifying where spare part waste management can be applied to a CMMS so as to obtain recommendations for implementing spare part waste management in CMMS. The results showed that the addition of spare parts waste management modules to the CMMS through the spare parts management function in industrial facilities can be carried out and produce output. By applying the right analysis criteria, it can identify which spare parts can actually be reused, sold, or recycled. This research highlights the importance of CMMS implementation in spare parts waste management in industrial facilities. The results provide guidance for similar facilities to improve waste management efficiency and reduce environmental impact and unnecessary operational costs.***

Indexed Terms- ***Computerised Maintenance Management System, Waste Management, Spare Parts, Prototype***

I. INTRODUCTION

A Computerised Maintenance Management System (CMMS) can support maintenance productivity by tracking the movement of parts, allowing operators to report faults faster; improving communication between operations and maintenance personnel more reliably; developing PM schedules in a timely manner; providing maintenance managers with information to have better control over their departments; and offering accountants information on machines to enable capital expenditure decisions to be made (Rastegari et al., 2016) Manufacturing industries and other production facilities often face significant challenges in managing the waste generated by routine replacement of component parts. In particular, a Computerised Maintenance Management System (CMMS) can handle maintenance transactions in the same way that an Accounting Information Management System can manage financial transactions. In the case of asset maintenance, transactions are work orders rather than invoices, and inventories are given by work backlogs and spare-parts stocks (Fumagalli et al., 2009).The process of replacing parts is an integral part of equipment maintenance, and while such replacements are necessary to ensure optimal performance, the management of the waste generated is often a complex issue.

Increased awareness of environmental impacts, increasingly stringent regulatory policies, and pressure to reduce operational costs have prompted industrial facilities to pay more attention to spare parts waste management. Poorly managed waste parts can cause negative impacts, both environmentally and financially. Using smart technologies (either in combination or separately in some cases) in industrial waste management can improve disposal or recycling operations. However, if such technologies are implemented in organisations without being specifically and scientifically formulated and without considering their impacts, they will be useless and

may even burden the organisation with huge costs (Fatimah et al., 2020).

In an attempt to address these issues, the implementation of a Computer Care and Maintenance Management System (CMMS) has become increasingly relevant. CMMS is software specifically designed to help industrial facilities efficiently manage and monitor maintenance and repair activities. However, the success of CMMS implementation in reducing spare parts waste and optimising inventory management still requires further research. Effective management of spare parts waste is not just about reducing negative environmental impacts, but also about long-term cost savings and more efficient management of resources. Therefore, this research will analyse the spare parts waste generated, add modules related to spare parts waste management to the Computerised Maintenance Management System (CMMS) module specifically on spare parts management as a suitable tool that has the potential to improve spare parts waste management and minimise negative impacts.

II. LITERATURE REVIEW

A. Previous Research

Previous research aimed to implement an integrated CMMS-RCM-CBM system to support Industrial Power Supply areas, specifically areas where main transformers are installed CMMS, tools for RCM analysis and CBM systems currently support industrial maintenance management. Each system has been shown to provide benefits to maintenance management in its own right, at least improving the efficiency of the maintenance process. This work presents the proposal of a new data model to enable the development of an integrated system that combines the features of all three systems, thus promoting synergies between them. Several benefits can be obtained thanks to the adoption of an integrated system type system, namely better analysis of maintenance actions so as to revise maintenance plans and improve the effectiveness of maintenance actions (Campos et al., 2010). In another study, the concept of group technology was used in database development, and a prototype of a computerised maintenance management system was designed in the maintenance department of a metal production company. The poor maintenance management system caused many discrepancies between the scheduled machine maintenance and its execution. To speed up and simplify information retrieval, a maintenance management system was designed with the development and grouping of spare parts inventory group technology (Reza Maulana, 2015). Overall, although there are several previous studies that discuss CMMS and waste management, no specific information has been found regarding the application of spare parts waste management in CMMS. Further research is needed to explore this topic in more depth. Especially regarding the addition of this module to the CMMS system.

B. Waste Management

Waste management has become a very important issue over the past few decades, mainly due to the complexity of the waste stream and the ever-increasing volume. Often, the decision-making process for efficient waste management requires the consideration of a large number of usually conflicting criteria to come up with an optimal solution among various alternative scenarios (Achillas et al., 2013). Waste management can be defined as the discipline associated with waste control, collection, storage, transfer and transport, treatment and disposal of waste in a manner consistent with the best principles of public health, economics, engineering, conservation, aesthetics, and other environmental considerations (Narayan Gambhire, 2023).Industrial waste exists in such quantity and variety that it inspires entirely new products in industry. At different times, petroleum spirit, coal tar, glycerin, and their derivatives, are externalities of production that are gradually being revalued as essential products. However, far more waste is disposed of than is reused. As such, industrial waste poses a much greater risk to the environment and human health and safety, leading to a worldwide debate around pollution from resource extraction and commodity manufacturing (Reno, 2015). So to develop a sustainable e-waste system starts with understanding the culture in which the material flow takes place (Kahhat et al., 2008).

C. Spare Parts

Spare parts refer to the requirements for keeping owned equipment in a healthy operating condition by

meeting repair and replacement needs caused by breakdowns, preventive maintenance, and predictive maintenance (Baluch et al., 2013). The key points about spare parts are:

- Spare parts are essential to ensure continuity of operations in industries such as manufacturing, transport, and construction. Spare parts provide a quick and cost-effective solution to equipment breakdowns, minimising downtime and loss of productivity (Roda et al., 2014).
- Spare parts can be classified into two main categories: consumables (e.g. filters, lubricants) and non-consumables (e.g. motors, bearings) (Kulshrestha et al., 2024).
- When selecting spare parts, important criteria to consider include compatibility, quality, availability, cost, and warranty (Kulshrestha et al., 2024).
- Spare parts inventory management involves challenges such as demand forecasting, supply chain network design, and joint optimisation of maintenance and inventory (Mouschoutzi & Ponis, 2022).
- Proper spare parts management can provide benefits such as reducing downtime, increasing productivity, and extending equipment life (Kulshrestha et al., 2024).

D. Computerised Maintenance Management System

A Computerised Maintenance Management System or CMMS can be used to manage a database containing information about a company's maintenance activities. Identifying which machines need maintenance and which warehouses provide the necessary supplies for the maintenance process are some examples of how this data helps employees manage assets more efficiently (Daryl Mather, 2002). Common modules contained in a CMMS (Bagadia, 2008) are

- Work Order: Scheduling of work, allocation of manpower, materials required, costs required, and records of information relevant to the process involved, and suggestions for follow-up action. In work orders there are also several sub-sections such as planned maintenance (Preventife Maintenance) and unplanned maintenance (Breakdown & Corrective).
- Asset Management: Relates to equipment and assets including repair activities, specifications, purchase dates, warranty information, repair history and other information needed by management and repair workers.
- Inventory Control: Management to manage spare parts, equipment and other materials including the warehouse location of these materials. Determines when materials should be purchased, records of purchases and returns.
- Labour/Employee Management: Manage the data of employees working in the repair department. And manage the access authority of each worker related to their respective job desks.

E. Data

According to the Big Indonesian Dictionary, the term data comes from the word ‘datum’ which means facts or materials information collection of events raised from a reality. Data can be in the form of numbers, letters, or special symbols or even a combination of them. Raw data still cannot provide information to users, so it needs further processing. Data processing is the manipulation of data into a form that is more useful and more meaningful in the form of information (Raymond Mcloed & Jr. George P. Schell, 2008). Based on the level of data complexity, data levels can be arranged into a data hierarchy, ranging from simple to complex. The data hierarchy can be divided into six levels, namely Bit, Byte, Field, Record, File, and Database (Edhy Sutanta, 2011).

In the database system, there are components that must be fulfilled in order to form a database system. According to (Carlos Coronel & Steven Morris, 2019) the database system consists of five main parts, namely: Hardware, Software, People, Procedures, and Data.

In developing the data, ERD is needed. ERD is the final result of the analysis process of the system reviewed by a system analyst. The E-R model is a detailed logical representation of a particular organisation or business area. The E-R model consists of several basic components, namely (Kadir, 2010): Entities, Relationships, and cardinality.

F. Software Prototyping

Prototyping is a very useful data collection method to complete the system development life cycle. (Kendall, 2010). By using prototyping, there are four main stages in software development, according to (Sommerville, 2011) the first, setting the purpose of the prototype by identifying problems in the system to be prototyped. The next step is to define the functions of the prototype to suit user needs. The third step is to develop the prototype by using logical design to implement the concepts that have been made. The last step is to assess the prototype results by comparing them with user needs. The following shows the prototype development process.

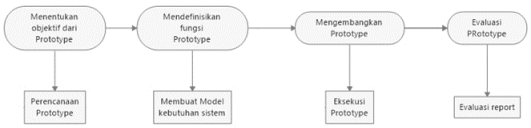

Figure 1: Prototype Development Process

III. RESEARCH METHODOLOGY

The method used in this research is software prototyping. Prototyping is the development and testing of a working model of an application function through an iterative interaction process. Before prototyping, the author collected data in several industrial sectors regarding spare parts waste in a part of the area in a particular industrial sector. Then waste grouping is carried out before adding a waste management module to a spare parts management function in the maintenance management system. So that from this process it can be seen the details that must be added in a spare parts management function in a maintenance management system. The research Flowchart is depicted in Figure 2.

Figure 2. Research flow diagram

A. Analysis

At this stage, system research is carried out and data collection is carried out to understand the information system to be designed, with the method of collecting data information, analysis and identification, and data processing for the needs of the system to be designed. Data Collection : In this process the researcher collects data regarding CMMS inventory data records regarding spare parts, and problems in managing spare parts waste.

Analysis and Identification : Identification and analysis are carried out from inventory records, problems that occur when managing and handling spare parts. As a basis for compiling Entity List and Entity Relational Diagram.

Data Processing : At this stage, the preparation of the entity list is carried out, and the preparation of the Relational Diagram. Then the grouping of waste from literature sources is carried out. So that we get a module that we can input in the development of prototypes.

B. Research Design

At this stage, data processing is carried out for prototype design. Workflow prototype, entitiy list and Entity Relational Diagram are obtained. As a basis for prototype design. The following is a table for the entity list and attributes

Table 1. List of Entities & Attributes

Entity	Attribute
Mesin	kode_mesin, nama_mesin, tahun_pembuatan, tipe
Sparepart	kode_sparepart, nama_sparepart, jenis_sparepart, jumlah_sparepart
Mekanik	kode_mekanik, nama_mekanik, alamat, telpon
Kerusakan	kode_kerusakan, nama_mesin, Deskripsi_kerusakan, tanggal_kerusakan, jam
Jadwal Perawatan	kode_jadwal, nama_mesin, jenis_perawatan, tanggal_perawatan
Perbaikan	kode_perbaikan, kode_kerusakan, nama_mekanik, nama_sparepart, kode_jadwal, jumlah_sparepart, tanggal_perawatan, keterangan, status
Tindakan Perawatan	kode_perawatan, kode_jadwal, nama_mekanik, tanggal_perawatan, keterangan, status
Material Bekas	Kode_Material, nama_limbah, jumlah_limbah, bentuk_limbah, jenis_limbah, penggunaan_kembali, tempat_penyimpanan, tanggal_masuk, keterangan

Then the ERD of the entilisation is compiled. The workflow is described to refine the design of the prototype

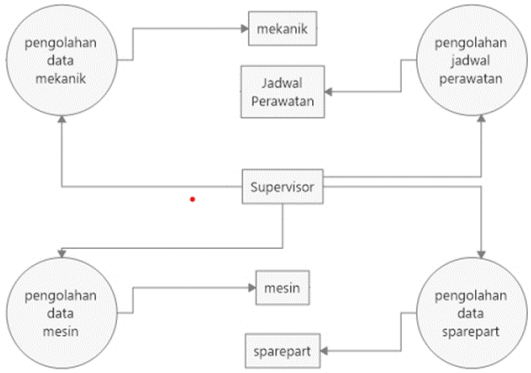

Figure 3. Workflow

Workflow describes the workflow and assignments in the prototype design so that user authority in this prototype can be arranged in such a way as to suit the needs. Authority is described as follows.

Table 2. Assignment List

User	otoritas sistem	keterangan
Supervisor (admin)	input data mekanik	
	input data mesin	
	input data sparepart	
	input jadwal perawatan	
	input data kerusakan	
	input data material bekas	
	menugaskan mekanik melakukan perawatan	
	menugaskan mekanik melakukan perbaikan	
mekanik	input data tindakan perawatan	berdasarkan input data perawatan dari supervisor
	input data tindakan perbaikan	berdasarkan input data kerusakan dari supervisor

IV. RESULTS

A. Data

The physical design is the actual design of the logical design that has been adapted to PHPRad, which is the software of choice in creating this database. At the physical database design stage, the entities have turned into this table.

Table 3. Physical Database

Database Fisik Entitas Mesin			
FieldName	FieldType	Size	KeyType
Kode_mesin	INT	11	primary
Nama_mesin	VARCHAR	20	
tahun_pembuatan	VARCHAR	255	
Tipe	VARCHAR	20	
Database Fisik Entitas Sparepart			
FieldName	FieldType	Size	KeyType
Kode_sparepart	INT	11	primary
Nama_sparepart	VARCHAR	25	
jenis_sparepart	VARCHAR	25	
jumlah_sparepart	VARCHAR	255	
Database Fisik Entitas Kerusakan			
FieldName	FieldType	Size	KeyType
Kode_kerusakan	INT	11	primary
nama_mesin	VARCHAR	255	
deskripsi_kerusakan	VARCHAR	255	
tanggal_kerusakan	DATE		
jam	TIME		
Database Fisik Entitas Perbaikan			
FieldName	FieldType	Size	KeyType
Kode_Perbaikan	INT	11	primary
kode_Kerusakan	VARCHAR	255	
Nama_mekanik	VARCHAR	255	
nama_Sparepart	VARCHAR	255	
kode_jadwal	VARCHAR	255	
jumlah_sparepart	VARCHAR	255	
tanggal_perawatan	DATE		
keterangan	VARCHAR	255	
status	VARCHAR	255	
Database Fisik Entitas Material Bekas			
FieldName	FieldType	Size	KeyType
Kode_Material	INT	11	primary
nama_limbah	VARCHAR	25	
jumlah_limbah	VARCHAR	25	
bentuk_limbah	VARCHAR	255	
jenis_limbah	VARCHAR	255	
penggunaan_kembali	VARCHAR	255	
tempat_penyimpanan	VARCHAR	255	
tanggal_masuk	DATE		
keterangan	VARCHAR	255	

B. User Interface Design

The purpose of UI design is to make it easier for people using the system (managers and mechanics). Some elements to consider when designing the UI are colours, form layout, and fonts. To make the UI easier for users, it is also necessary to consider the design and layout of command buttons and captions. (Kendall, 2010) describes the main goal in designing UI is to help users and businesses get information effectively and easily.

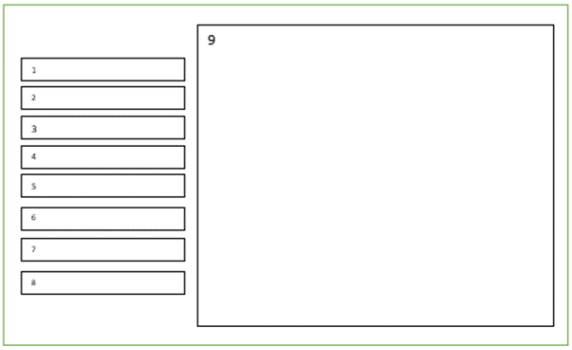

Figure 5. UI design

C. Database Implementation

In the database implementation stage, the previously designed tables are created in the physical database design subsection. These tables will contain all the data from the care management information system. To implement the database with PHPRad is done as follows.

1. Activating XAMPP as a database storage
2. Open PHPRad and select blank and new creation
3. In the database column, fill in the name field according to the prepared entity
4. After everything is filled in, click save and give a label

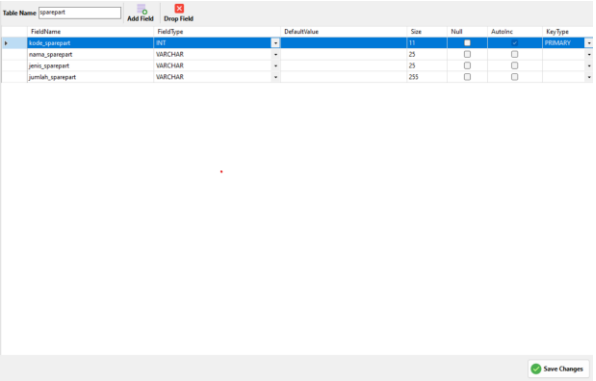

Figure 5. Design of Spare Parts Table View

D. User Interface Implementation

User interface implementation is made based on the previous design stage. The following is the UI implementation with PHPRad.

1. Login Form : Will appear for the first time when run. In this form the user is required to input the appropriate username and password. The following is the implementation of the login form in the following image.

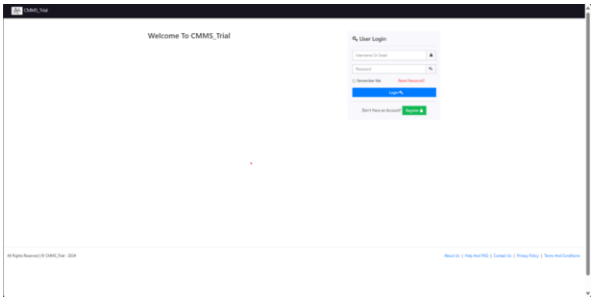

Figure 6. User Login UI Design

2. Master Form : This form is the main form that can access all feature forms that have been created. The spare parts function of each machine along with the category for each spare parts waste is seen in the spare parts section. Pelleting of spare parts waste on the used material entity and as an output from the repair entity. Because when doing repairs. There is an exchange between new parts and used parts. This allows users to input used material data after repairs.

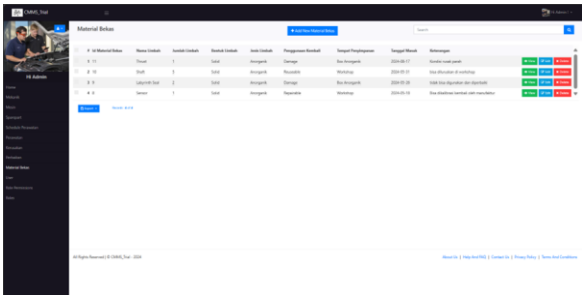

Figure 7. UI Design of Used Material Entity Master Form

V. CONCLUSIONS AND RECOMENDATION

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This completes the entire process required for widespread of research work on open front. Generally all International Journals are governed by an Intellectual body and they select the most suitable paper for publishing after a thorough analysis of submitted paper. Selected paper get published (online and printed) in their periodicals and get indexed by number of sources.

CONCLUSION

Based on the research that has been done, the following conclusions can be drawn.

A. After carrying out the prototyping stages in the process of system analysis and design. Obtained an information system design that can process data and present information not only about machine maintenance and spare parts inventory but information related to spare parts waste management. With the addition of this module, spare parts that have been used can be recorded and measured whether the spare parts that have been used are still in the category of feasible use or are completely unusable and even how these spare parts can be grouped according to the type of material.

B. Prototype Computerised Maintenance Management System (CMMS) has been designed and built using PHPRad. The system created can display maintenance scheduling and damage that must be carried out repair activities. Spare parts that have been used can be put back into the inventory that has been adjusted. The system can compile upcoming maintenance schedules automatically after inputting maintenance and repair actions. Accounts can set access levels for CMMS settings so that they can be adjusted to the needs of the Company.
C. Problems such as recording and measurement failures can be resolved by complying with the procedure that every time a spare part is changed, there must be a used spare part that is inputted back into the system. Process error damage can be prevented by ensuring the input of spare part data when a damage is found correctly, unmeasured spare part waste can be resolved by knowing the amount inputted, the description of waste by category is expected to directly sort used spare parts in terms of usability, shape, and type. Therefore, spare parts that have been used can be measured and recorded and know the conditions and future actions.

From the research that has been done, the authors provide several suggestions for further research in order to develop and expand the benefits of related knowledge :

A. The addition of other modules is possible so that the functions of CMMS can better cover other functions related to maintenance management and spare parts inventory.
B. It is hoped that the information system created can be integrated with a higher level layer of Management Software.
C. It is recommended that each user log in using their own me. So that mechanics can only input their own data

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