International journal of science, engineering, and information technology
Volume 07, Issue 02, July 2023
Journal homepage: https://journal.trunojoyo.ac.id/ijseit

Determination the Critical Component Machine using AHP Method for Reliability Centered Maintenance

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ABSTRACT

Identification of critical components is one of the important steps in reliability-centered maintenance. This paper aims to develop a strategy to integrate key factors related to maintenance with component/sub system criticality. To analyze the criticality of a component, five criteria are used, namely duration of maintenance, probability of failure, level of risk of production process disruption due to component failure, facilities required for repair, and maintenance costs. A hierarchical network is created to identify important components based on these criteria. The Analytical Hierarchy process is one method to facilitate maintenance managers in making decisions in prioritizing maintenance of various components/failure modes so that the maintenance system runs more effectively and efficiently. Theoretical principles and real cases from an industry are analyzed to explain the implications of the proposed method. The results of the study provide a realistic solution in determining the priority of critical components in a reliability-centered maintenance plan.

Keywords: Reliability Centered Maintenance, decision making, critical component, Analytical Hierarchy Process

Article History
Received 30 May 23 Received in revised form 02 June 23 Accepted 03 July 23

1. INTRODUCTION

Competition in the industrial field, requires companies to be able to provide quality products and services for consumers. Industrial companies, especially manufacturing, have the necessary machines to support the creation of a smooth production process, namely machines that have vital components to carry out operational activities. [1]. Every company tries to reduce the risk of losing production time, one of the causes of which is machines that experience malfunctions. Efforts are being made to minimize the occurrence of these malfunctions, one of which is by taking maintenance actions [2].

Maintenance is an action taken in order to maintain or maintain a machine unit or make repairs until the machine is in an acceptable condition. In general, maintenance is an activity in order to maintain the facility by making repairs and maintenance in order to create satisfactory operational conditions in the production process [3]. The benefits of maintenance are to extend the usefulness of assets and to ensure the availability and operational readiness of all equipment [4].

Basically, Reliability centered maintenance (RCM) is the most efficient strategy compared to the existing maintenance supervision strategy. RCM is a systematic process for optimizing the results of maintaining an asset with a cost-effective method of maintenance management in terms of reliability [5]. The RCM process basically consists of several stages, one of the most important of which is the identification of critical components that have a major influence on system reliability. Therefore, by focusing maintenance priorities on critical components to avoid failure, we can allocate our resources effectively and efficiently [6].

Analysis of critical components is very important because the failure of a critical component can cause the failure of a system. Many critical analyzes have been carried out on critical components using Failure mode, effects, and criticality analysis (FMECA) as has been done by Nakandhrakumar, et al in identifying critical components in the Hovercraft assembly process. [7]. Khaira and Dwivedi have identified critical components to increase equipment availability in a graphite manufacturing industry [8]. Koksal and Ozdemir have studied determining the optimal component maintenance process for a power transmission system [9]. From the literature it is clear that it is very important to identify the critical components in order to obtain an optimum maintenance system while minimizing maintenance costs. Along with the increasing complexity of manufacturing machines, it will be very difficult to identify components based on failure modes and their effects, so it is necessary to make efforts to determine the key factors that affect a component so that the maintenance system runs optimally. The Analytical Hierarchy Process (AHP) has been recognized as a flexible and powerful multi-criteria decision making method in determining decisions for complex problems by considering both qualitative and quantitative aspects. [10]. By reducing complex decisions to simple comparisons and ranking, this paper will discuss the determination of critical components using the AHP method in order to

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obtain the best decisions and provide clear reasons for selected components based on criteria related to maintenance.

2. METHODS

Identification of critical components of a system is a multi-criteria decision making problem as it involves multiple criteria and sub-criteria. The Analytical Hierarchy Process (AHP) is a method introduced by Thomas Saaty (1980) which is used to determine the ranking or priority order of several alternatives based on certain criteria. AHP allows decision making in solving problems in a structured step and systematic evaluation of several criteria. In processing using AHP, the term pairways comparison is known. Pairwise comparisons were made for each criterion and each alternative. There are 3 principles in applying the AHP method, namely compiling a hierarchy, determining priorities, and logical consistency. Pairwise comparisons refer to a scale of 1-9 to assess the importance between elements or between criteria, as shown in Table I [10].

Table I Paired Comparison Scale AHP Method

Score	Definition
1	Both elements are equally important
3	One element is bit more important than the other
5	One element is more important than the other elements
7	One element is definitely more absolutely important than the other elements
9	One element is absolutely more important than the other elements
2,4,6,8	The value between 2 adjacent consideration values

Since its introduction, AHP has been widely applied to various decision-making problems such as risk management [11], [12], supplier selection [13]–[16], performance evaluation[15], [17] and others. In this study, critical sub-components will be determined by ranking each sub-component using the AHP (Analytical Hierarchy Process) method on a machine for the Surya Kencana Food industrial business, namely the wafer stick baking machine. The AHP method was chosen because the determination of the critical sub-components has several criteria, so the first step is to determine the criteria for further use as a consideration in determining the critical sub-components.

A component is said to be critical if the failure of the component results in a serious failure [18]. Several criteria are used to determine the criticality of a component so that the component with the highest value of these criteria can be prioritized in maintenance to prevent the impact of system failure. At this stage, interviews were conducted with maintenance managers to determine the criteria for selecting critical components. Several criteria and sub-components used in this study are illustrated in Table II and Table III.

Table II Criteria Critical Component

Notation	Criteria
K1	Maintanance Duration
K2	Probability of Failure
K3	Production Interruption Risk
K4	Facility required to repair
K5	Maintanance Cost

Table III Tested Components

Notation	Sub Component
S1	Motor
S2	Nokseal
S3	Bearing
S4	Nozzle
S5	Roll
S6	Minicuter

- Maintenance duration is the length of repair of a sub component. The process of repairing some components sometimes takes a long time which results in large system downtime. Therefore, components that have a long enough downtime become more critical components.
- Probability of failure is the probability of failure of a sub component. The frequency of failure and its effect on the system will affect the availability of the system, so components with a high failure probability value need to be prioritized in the maintenance system.
- Production Interruption Risk shows how severe the effect of damage to a sub-component on production activities that must be carried out.
- The maintenance system requires the facilities needed for repair. The complexity of a component will require the availability of more repair resources. To anticipate the occurrence of long downtime, it is necessary to carry out a maintenance strategy for critical components by providing the facilities needed for repairs.
- Maintenance cost is an important factor in determining the criticality of a component. If a component has a higher maintenance cost then it needs to be given a higher criticality value.

The hierarchical structure in determining the critical components can be seen in Figure 1.

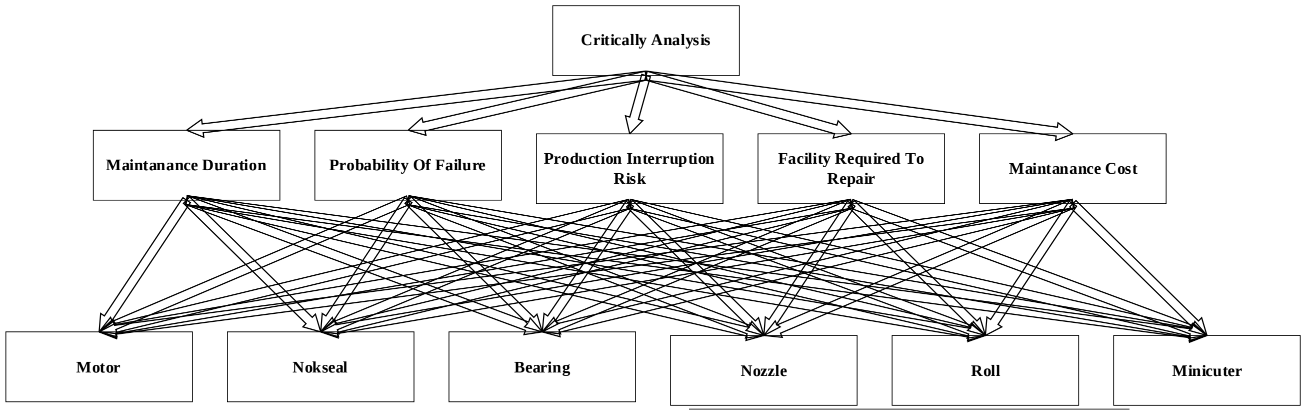

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Figure 1 Hierarchical structure in determining critical components

3. RESULT

The next stage after determining the criteria and alternatives is determining the weights and priorities by means of pairwise comparisons between criteria. Table IV shows the results of pairwise comparison assessments between criteria carried out by several maintenance department staff by discussing together.

Table IV Paired Comparison Between Criteria

	K1	K2	K3	K4	K5
K1	1	3	0,33	3	3
K2	0,33	1	0,2	3	3
K3	3	5	1	7	7
K4	0,33	0,33	0,14	1	0,33
K5	0,33	0,33	0,14	3	1

After determining the value of the relationship between criteria, normalization is carried out to obtain pairwise comparison results as shown in Table V.

Table V Paired Comparison Results Between Criteria

	K1	K2	K3	K4	K5
K1	0,200	0,310	0,183	0,176	0,209
K2	0,067	0,103	0,110	0,176	0,209
K3	0,600	0,517	0,550	0,412	0,488
K4	0,067	0,034	0,079	0,059	0,023
K5	0,067	0,034	0,079	0,176	0,070

From the comparison results, the priority order of the criteria is shown in Table VI.

Table VI Priority Value of Each Criterion

Rank	Criteria	Eigen vektor
1	Production Interruption Risk	0,513
2	Maintanance Duration	0,216
3	Probability of Failure	0,133
4	Maintanance Cost	0,085
5	Facility required to repair	0,052

In AHP, the goodness of judgment is evaluated with an inconsistency value. From the calculation results, the CR value of this comparison is less than 10%, which means it is consistent. From the comparison results, it is known that the production interruption risk criteria are the most important criteria in determining the critical sub-components. The criteria for production interruption risk are the most critical because when the wafer stick baking machine is damaged, it can disrupt production activities.

The next stage is a pairwise comparison between the sub-components based on each criterion. With the same steps, critical components will be obtained based on each criterion. After finding the weight of each component based on each criterion, then do the matrix multiplication of the eigenvector values on each criterion with the eigenvector values between the sub-components based on each criterion. The results of the comparison of sub-components between criteria and matrix multiplication can be seen in Table VII.

Table VII Relative Importance of Criteria and Sub Components

Overaall composite	Bobot kriteria	Motor	Nokseal	Bearing	Nozzle	Roll	Minicuter
Maintanance Duration	0,216	0,408	0,068	0,068	0,068	0,163	0,225
Probability of Failure	0,133	0,101	0,053	0,032	0,416	0,193	0,205
Production Interruption Risk	0,513	0,403	0,040	0,058	0,085	0,268	0,146
Facility required to repair	0,052	0,169	0,045	0,079	0,113	0,297	0,297
Maintanance Cost	0,085	0,497	0,037	0,056	0,134	0,172	0,105
Composite weight		0,360	0,048	0,057	0,131	0,229	0,175

Based on Table VII, it can be seen that the most important criteria in determining the critical weight, namely production interruption risk with a criterion weight value of 0.513 and the critical components based on these criteria sequentially are Motor, Roll, and Minicuter with a weight value of 0.360, 0.229 and 0.175 as sub -components that are prioritized in determining the maintenance strategy of the wafer stick machine.

4. CONCLUSION

Identification of critical components and their priority maintenance activities is an important step for RCM implementation. In this paper, the identification of critical components considered as a multi-criteria decision problem and a hierarchical network is developed using the Analytic Hierarchy Process (AHP). The evaluation criteria are determined based on the criticality of the component type and the importance of decision making for maintenance. This will provide a realistic solution to the decision-making problem for maintenance planning in prioritizing critical components for RCM procedures. From the analysis results, the most important criteria in determining critical components is production interruption risk with weight value of 0.513 This can be explained that if there is damage to a component it will interfere with the production process and can even cause the production process to stop. Based on the results of the analysis, if applied to the determination of critical components in a wafer stick baking machine, the motor component is a critical component that needs to be prioritized in determining a maintenance strategy centered on reliability with a weight value of 0.360.

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