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Prioritization of Industrial Assets Using SAW Method

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Abstract. The evaluation of industrial assets is an essential process to ensure the reliability and availability of equipment. The combination of data-based Key Performance Indicators (KPIs) and the input from maintenance technicians can provide a more comprehensive assessment of assets.

In this article, the Simple Additive Weighting (SAW) method was employed to combine data-based KPIs and the opinions of maintenance technicians in evaluating six industrial equipment. The results demonstrated that the amalgamation of these criteria is effective in identifying the most critical equipment for the production process.

These findings can be used to prioritise maintenance investments, which can contribute to enhancing the reliability and availability of the equipment.

Keywords. Industrial asset assessment, KPIs (Key Performance Indicators), Maintenance technicians' opinions, SAW method (Simple Additive Weighting method), Prioritization of maintenance investments

1. Introduction

Industrial maintenance is an essential process to ensure equipment availability and reliability. To achieve this, it is important to use indicators that allow for equipment performance evaluation and decision-making.

Maintenance Key Performance Indicators (KPIs) are indicators used to measure the performance of a process or system. They can be based on quantitative data such as downtime, maintenance costs, among others.

In addition to KPIs, maintenance technicians' opinions are a valuable source of information to assess equipment health and are often used in conjunction with indicator evaluations. Technicians possess practical knowledge of equipment and can identify issues that may not be detected by quantitative data-based KPIs.

This article presents an approach to combine KPIs with maintenance technicians' opinions to evaluate equipment health. The approach is based on the Simple Additive Weighting (SAW) method, a multicriteria method that allows for combining different criteria to make decisions.

The results of applying this approach to a dataset of six industrial equipment pieces showed that combining KPIs such as MTTR (Mean Time To Repair), MTBF (Mean Time Between Failure), and Downtime with maintenance technicians' opinions was effective.

These results can be used to prioritize maintenance investments, which can help improve equipment reliability and availability

2. Methods

2.1 Assets

Industrial assets are machinery and equipment, in this article, six industrial assets (machines) are being used, but an asset evaluation can involve thousands of assets depending on the size of the plant.

Tab. 1 - Assets.

Tag	Description
M1	CNC Milling Machine 1984
M2	Induction Furnace 1991
M3	Heller Machining Center 1995
M4	Cabin Conveyor 1998
M5	Annealing Oven xxxx
M6	Traufa Painting Robot xxxx

2.2 Criteria

The most commonly used KPIs by maintenance departments were selected:

Criterion 1 (C1) - Downtime: Equipment downtime during the year (in hours).

Criterion 2 (C2) - MTBF: Mean Time Between Failures (in hours).

$$\text{MTBF} = \frac{\sum(\textit{Start of Downtime} - \textit{Start of Uptime})}{\textit{Number of Failures}}$$

Criterion 3 (C3) - MTTR: Mean Time To Repair (in hours). Number of shutdowns: Number of failures that occurred.

$$MTTR = \frac{\textit{Total Maintenance Time}}{\textit{Number of Repairs}}$$

Criterion 4 (C4) - Number of failures: Indicates how many failures the equipment experienced during a year.

Tab. 1 - KPIs.

C1 Downtime	C2 MTTR	C3 MTBF	C4 N°of Failures
3	0.6	1100	5
5	2.5	2750	2
40	13.13	1833	3
20	5	110	4
2	0.4	1100	5
15	2.5	916.666	6

The criterias C5 to C7 are assessments by maintenance technicians, assigning a value from 1 to 4, where 1 represents higher criticality and 4 represents lower criticality.

Criterion 5 (C5) - Electrical: Maintenance technician's opinion on the electrical condition of the equipment.

Criterion 6 (C6) - Mechanical: Maintenance technician's opinion on the mechanical condition of the equipment.

Criterion 7 (C7) - Spare Parts: Maintenance technician's opinion on the need for spare parts for the equipment.

Tab. 2 - Technical Evaluation.

C5 Electrical	C6 Mechanical	C7 Spare Parts
2	1	2
3	3	3
4	4	4
4	2	1
2	1	1
1	1	1

2.3 Application of the SAW Method

The Simple Additive Weighting (SAW) method is a well-known and widely applied multicriteria decision-making (MCDM) approach in the literature. This method obtains criteria weights from the decision maker (DM) and considers the normalized value of criteria in each alternative in its procedure.

In this article, the SAW method is applied to rank maintenance assets. The assets serve as the alternatives in the SAW method.

The score for each asset is calculated in two steps:

Calculating the asset's score for each criterion by multiplying the criterion weight by the asset's normalized value for that criterion.

Calculating the total asset score by summing the scores obtained for the asset across all criteria. Finally, the assets are ranked in descending order of their total scores. The top positions in the ranking are occupied by assets with the highest scores (most critical). In other words, the SAW method is a simple and effective approach for combining criteria of varying importance and making decisions based on the overall score of the alternatives.

$$x_{ij} = \frac{a_{ij}}{\sum_i a_{ij}}$$

Benefit.

$$x_{ij} = \frac{1/a_{ij}}{\sum_i 1/a_{ij}}$$

cost

The weights were assigned to the criteria based on their importance to maintenance objectives using the Direct Rating Method [2]. This method relies on soliciting a subjective assessment of KPI weights from a group of experts. Experts are asked to assign a rating from 1 to 10 for each KPI, with 1 being the lowest weight and 10 being the highest weight. Then, each rating is divided by the sum of all the ratings.

$$p_i / \Sigma p_i$$

Direct Rating Method

$$u_i = \sum_{j=1}^{m} w_j r_{ij}$$

Simple Addictive Weight Raking

3. Results

The proposed approach was applied to a dataset of 6 industrial equipment. The results demonstrated that the combination of data-based quantitative KPIs with maintenance technicians' opinions is effective in identifying the most critical equipment for the production process.

The SAW method proved to be highly efficient in this case, as it accurately identified the most critical equipment. Additionally, the method can be applied to spreadsheets, making implementation easy and accessible to companies of all sizes.

Another notable aspect is the scalability of the method. This means that it can be applied to other assets, contributing to impartiality and better decision-making.

Tab. 1 - Assets.

Tag	Description	Ranking
M1	CNC Milling Machine 1984	4
M2	Induction Furnace 1991	5
M3	Heller Machining Center 1995	1
M4	Cabin Conveyor 1998	3
M5	Annealing Oven xxxx	6
M6	Traufa Painting Robot xxxx	2

4. Discussion

The research is relevant to the field of maintenance as it provides an effective approach to identifying the most critical equipment for the production process. The combination of data-based quantitative KPIs with maintenance technicians' opinions offers a holistic view of assets, which is essential for informed decision-making.

The research contributes to the maintenance field in several ways. Firstly, it provides a systematic approach to identifying the most critical equipment. Secondly, it demonstrates the effectiveness of combining data-based quantitative KPIs with maintenance technicians' opinions. Thirdly, it is accessible to companies of all sizes since it can be implemented in spreadsheets.

The research does have some limitations. Firstly, it was applied to a relatively small dataset. Secondly, it does not consider subjective factors such as resource availability.

Future research could explore the following topics:

The application of the proposed approach to larger datasets.

Considering subjective factors, such as resource availability.

Developing a method to update asset rankings over time.

5. Conclusion

The research results demonstrated that the proposed approach is capable of accurately

identifying the most critical equipment. Furthermore, the approach is accessible to companies of all sizes as it can be implemented in spreadsheets, The SAW method is also easy to explain, which would facilitate the training of new employees.

Future research could explore the application of the proposed approach to larger datasets and the consideration of subjective factors such as resource availability and maintenance cost.

6. References

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