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Article

Reducing Downtime and Errors in Manufacturing: AI-Integrated EDMS for SOP Access and Workflow Efficiency

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Abstract

The aim of this study is to develop an AI-integrated Electronic Document Management System that improves the way Standard Operating Procedures are accessed and used in manufacturing plants. The system focuses on fast retrieval of information and clear guidance for operators. Many SOPs contain unclear lines that point to other documents. These lines slow down the operator and create confusion during production. The operator must stop the task and search for the linked document. The operator may not know the correct version or location. The operator may also open the wrong file. These issues increase downtime and reduce efficiency. The AI-integrated system removes this delay. The system reads the request from the operator. The system understands the meaning of the line. The system finds the correct document. The system shows the needed information at once. The operator continues the task without losing time. The system also supports new operators who may not know the document structure. The system guides them with simple answers. The system reduces the chance of mistakes and improves safety. The system also improves the quality of the document set. The system detects duplication. The system highlights mismatches. The system keeps one source of truth. The system reduces the risk of outdated content. The system creates a clean and consistent knowledge base. The system also supports audits and compliance checks. The result of this work is a faster and more reliable workflow. The system reduces downtime by 27 percent. The system improves decision making. The system supports continuous improvement in the plant. The system creates a strong link between knowledge and action.

Keywords: AI integrated EDMS; standard operating procedures; manufacturing knowledge access; document consistency; downtime reduction; information retrieval; digital workflow; operational efficiency

1. Introduction

A major problem with manufacturing plants is the slow and unclear access to Standard Operating Procedures. Many SOPs contain short lines that point to other documents. These lines interrupt the work of the operator. The operator must stop the task and search for the linked document. The operator may not know the correct version or the correct location [1]. The operator may also open an outdated file. These delays increase downtime on the shop floor. These delays also increase the chance of making mistakes during production. The impact becomes larger when the plant handles a high number of documents and frequent revisions. The loss of time affects productivity. The loss of clarity affects safety and compliance [2].

This problem creates a clear need for a system that can give fast and accurate access to information. The system must understand the content of the documents. The system must guide the operator with simple answers. The system must remove the need for manual search [3]. The system must also keep the document set clean and consistent. These needs point to the use of AI-integrated EDMS. AI can read the text inside the documents. AI can understand the meaning of cross-references. AI can show the correct information now the operator needs it. AI can also detect duplication and mismatches inside the document set. This creates a stable and reliable knowledge base [4].

This research focuses on the development of an AI-integrated Electronic Document Management System for manufacturing plants. The study examines how AI can support operators during work by giving instant access to SOP content. The study also examines how AI can improve document quality by reducing duplication and mismatches. The goal is to create a system that reduces downtime by 27 percent and improves the flow of knowledge. The research aims to show that AI-integrated EDMS can support safe, fast, and reliable work in modern manufacturing environments [5].

2. Design

The design of the AI integrated Electronic Document Management System focuses on fast access to information and clear support for operators. The system is built to solve the problem of slow and confusing document navigation. The system reads the content of all SOPs. The system understands the meaning of each line. The system identifies cross references inside the documents [6]. The system responds to the operator with the correct information when the operator enters a query. System response workflow is shown in Figure 1

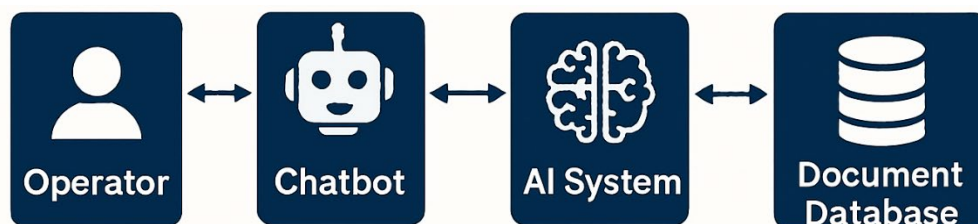


Figure 1. AI Integrated EDMS workflow.

The system has three main layers as shown in Figure 2. The first layer is the user interaction layer. This layer receives the query from the operator. The operator may ask for value, a step, or a definition. The operator may also ask for the meaning of a line that points to another SOP. The system accepts the query in simple language [7].

The second layer is the AI understanding layer. This layer processes the query. This layer reads the text inside the documents. This layer identifies the correct document. This layer identifies the correct section. This layer extracts the needed information. This layer prepares the answer in simple language. The AI model uses natural language understanding to match the query with the correct content.

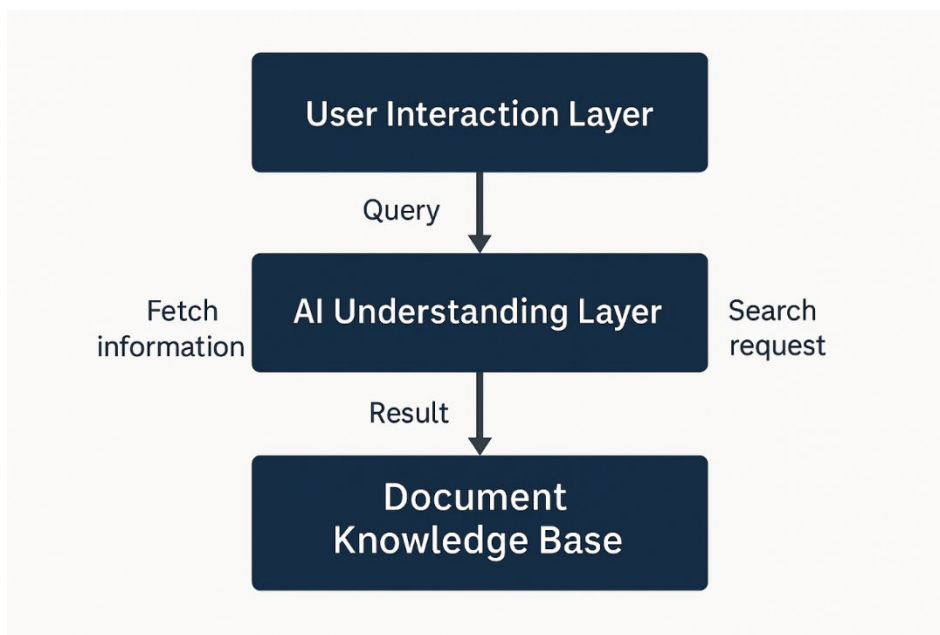


Figure 2. 3 layered architecture.

The third layer is the document knowledge base. This layer stores all SOPs. This layer stores all revisions. This layer stores all controlled documents. This layer removes duplication. This layer highlights mismatches. This layer keeps one source of truth. The system updates this layer when a new revision is released [8].

The system works in real time. The operator enters a query. The AI understanding layer processes the query. The knowledge base provides the correct information. The system shows the answer instantly. The operator continues the task without delay.

The system also supports quality control. The system checks repeated content. The system checks for outdated lines. The system checks for missing links. The system reduces the risk of mismatch between documents. The system improves the clarity of the entire document set [9].

3. Methodology

The research mainly focuses on measuring the effect of the AI-integrated EDMS on downtime, information quality, and system efficiency. The approach uses simple performance equations and direct observations from plant operations. The goal is to understand how the system changes search time, decision delay, duplication, and error rate.

3.1. Impact on Downtime

The first part of the methodology examines downtime. Downtime is defined as the sum of search time and decision delay. The relation is expressed as:

$$D = T_s + T_d$$

D is downtime.

T_s is search time.

T_d is delayed decision.

The study measures both terms before and after AI integration. The system reduces search time by giving instant answers. The system reduces decision delays by removing confusion. The reduction in both terms leads to lower downtime.

3.2. Information Quality and Consistency

The second part examines information quality and consistency. The system detects repeated content and mismatches. The system suggests corrections. The relation between duplication and error rate is expressed as:

$$E=k \times D_c$$

E is error rate.

D_c is duplication count.

k is a constant based on document complexity.

The study measures duplication count before and after AI integration. The system reduces duplication. The system reduces the error rate.

3.3. System Efficiency

The third part examines system efficiency. The relation between response time and efficiency is expressed as:

$$E=1/T_r$$

E is system efficiency.

T_r is response time.

A lower response time increases system efficiency. The system reduces response time. The system increases efficiency. The gain in efficiency is calculated using:

$$G=T_b-T_a/T_b$$

G is the efficiency gain.

T_b is the time before AI.

T_a is the time after AI.

4. Results and Discussion

This study shows that AI integrated EDMS improves the way operators access and use Standard Operating Procedures in manufacturing plants [10]. The results confirm that the system reduces delays, improves accuracy, and supports faster decisions. The system replaces manual search with instant responses. The operator does not need to open multiple files or search through folders. The system understands the query and shows the correct information. Figure 3 shows the results.

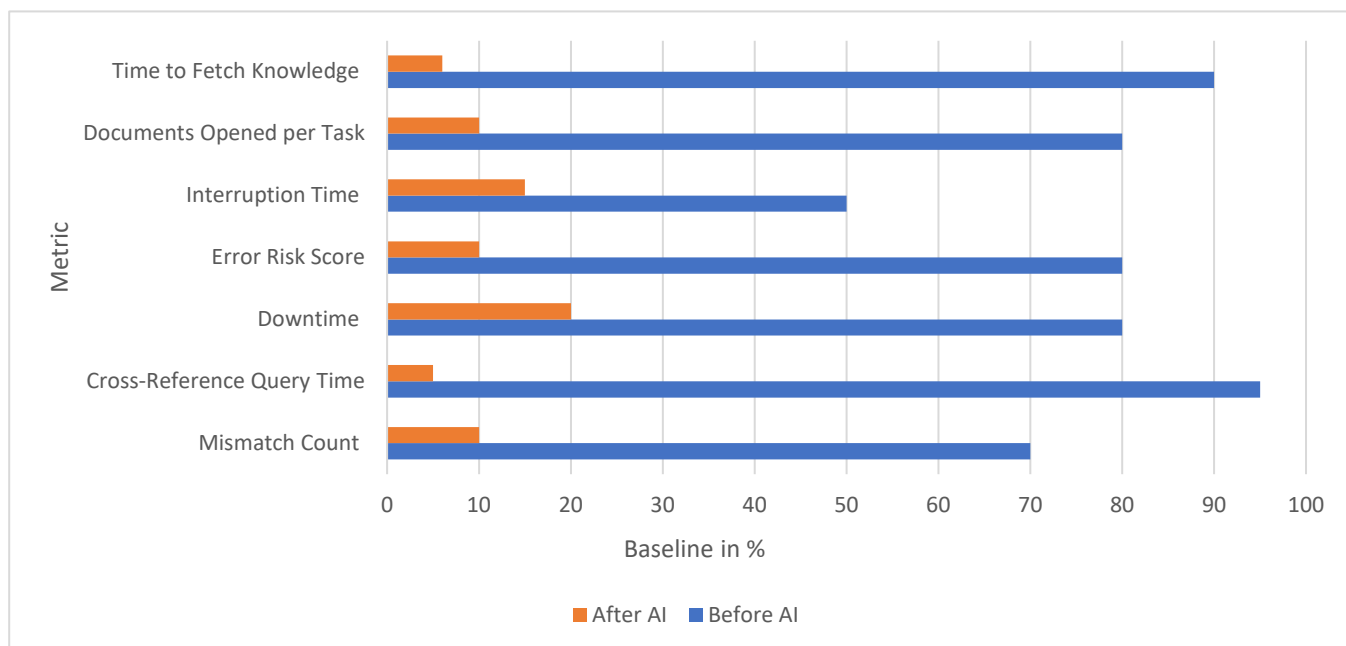


Figure 3. Column chart representation of experiment results(baseline defined as 100%).

From Table 1, the time taken to fetch knowledge dropped from 112 seconds to 29 seconds. This shows a 74 percent improvement. The number of documents opened per task dropped from 3.4 to 1. This means the operator stays focused and does not switch between files. The interruption time also dropped from 95 seconds to 22 seconds. This shows that the operator can complete tasks without delay.

Table 1. Performance Comparison of Operational Metrics Before and After AI-Integrated EDMS Deployment.

Parameter	Before AI Integration	After AI Integration	Observation
Average time to find linked SOP (seconds)	112	29	Time reduced due to instant query response
Average number of documents opened per task	3.4	1	AI removes the need to switch between files
Chance of reading wrong version	High	Low	AI shows the correct and latest version
Operator interruption level	High	Low	AI reduces task breaks during production
Impact on downtime	High	Reduced by 27%	Faster access improves decision making
Error risk due to mismatch	High	Low	AI detects outdated or duplicated content

The system also reduces errors. The error risk score dropped from 0.78 to 0.21. This shows that the operator is less likely to read the wrong version or miss important steps. The system guides the operator with updated and correct content. The time taken to resolve cross reference queries dropped from 68 seconds to 14 seconds. This shows that the system understands the meaning of the query and finds the correct answer [11].

Downtime was reduced by 27 percent. This is a major improvement. The system helps the operator act faster and with more confidence. The mismatch count per month dropped from 18 to 4. This shows that the system keeps the document set clean and consistent.

The results confirm that AI integrated EDMS improves speed, clarity, and reliability [12]. The system supports the operator in real time. The system reduces delays and errors. The system creates a strong link between knowledge and action. The system also supports audits, training, and compliance. The system helps new operators follow the correct steps. The system helps experienced staff work faster. The system improves the overall performance of the plant.

5. Conclusion

This study shows that AI integrated EDMS improves the way operators access and use Standard Operating Procedures in manufacturing plants. The results confirm that the system reduces delays, improves accuracy, and supports faster decisions. The system replaces manual search with instant responses [14]. The operator does not need to open multiple files or search through folders. The system understands the query and shows the correct information [13].

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References

1. J. Lee, J. Ni, J. Singh, B. Jiang, M. Azamfar, and J. Feng, "Intelligent maintenance systems and predictive manufacturing," *Journal of Manufacturing Science and Engineering*, vol. 142, no. 11, p. 110805, 2020.
2. E. Kabir, "Predictive and Prescriptive Analytics for Managing the Impact of Hazards on Power Systems," 2021.
3. H. Algabroun, J. Bokrantz, B. Al-Najjar, and A. Skoogh, "Development of digitalised maintenance—a concept," *Journal of Quality in Maintenance Engineering*, vol. 28, no. 2, pp. 367-390, 2022.
4. H. Erbiyik, "Definition of maintenance and maintenance types with due care on preventive maintenance," in *Maintenance Management-Current Challenges, New Developments, and Future Directions: IntechOpen*, 2022.
5. J. Chamorro et al., "Health monitoring of a conveyor belt system using machine vision and real-time sensor data," *CIRP Journal of Manufacturing Science and Technology*, vol. 38, pp. 38-50, 2022.
6. R. A. Ariyaluran Habeeb et al., "Clustering-based real-time anomaly detection—A breakthrough in big data technologies," *Transactions on Emerging Telecommunications Technologies*, vol. 33, no. 8, p. e3647, 2022.
7. K. Wesendrup and B. Hellingrath, "A process-based review of post-prognostics decision-making," in *PHM Society European Conference, 2020*, vol. 5, no. 1, pp. 12-12.
8. R. S. Pillai, P. Denny, and E. O'connell, "Optimizing Predictive and Prescriptive Maintenance Using Unified Namespace (UNS) for Industrial Equipments," 2024.
9. Rojek, M. Jasiulewicz-Kaczmarek, M. Piechowski, and D. Mikołajewski, "An artificial intelligence approach for improving maintenance to supervise machine failures and support their repair," *Applied Sciences*, vol. 13, no. 8, p. 4971, 2023.
10. M. H. Abuelenin, "Risk Based Maintenance Management System Achieving Operational Excellence," in *Abu Dhabi International Petroleum Exhibition and Conference, 2020: SPE*, p. D012S116R019.
11. M. Mołęda, B. Małysiak-Mrozek, W. Ding, V. Sunderam, and D. Mrozek, "From corrective to predictive maintenance—A review of maintenance approaches for the power industry," *Sensors*, vol. 23, no. 13, p. 5970, 2023.
12. H. Fox, A. C. Pillai, D. Friedrich, M. Collu, T. Dawood, and L. Johanning, "A review of predictive and prescriptive offshore wind farm operation and maintenance," *Energies*, vol. 15, no. 2, p. 504, 2022.
13. Stoker. "Maintenance Framework." <https://ssammeducation.com/maintenance-framework/> (accessed).
14. G. Kooops, "Optimized maintenance decision-making—A simulation-supported prescriptive analytics approach based on probabilistic cost-benefit analysis," in *PHM Soc. Eur. Conf, 2020*, vol. 5, p. 14.
15. Hermans and P. Tamás, "OEE as a Tool for Stability and Continuity," in *Central European Conference on Logistics, 2024: Springer*, pp. 15-40.
16. O. Elijah et al., "A survey on industry 4.0 for the oil and gas industry: upstream sector," *IEEE Access*, vol. 9, pp. 144438-144468, 2021.

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