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Development of Algorithm for Optimization of Smart Kitting Systems in Industry

Pravin Naik[1], S.G. Ankaliki[2].
[1]Postgraduate Student, [2]Professor & HOD, Department of Electrical and Electronics Engineering, Shri Dharmasthala Manjunatheshwara College of Engineering and Technology, Dharwad, Karnataka, India (An autonomous Institution affiliated to VTU, Belagavi.)

ABSTRACT

In the industry, smart factories are heavily dictated by the synergy between physical material handling and digital information flow. This study investigates the holistic transformation of the kitting process, addressing inefficiencies such as excessive travel distances, ergonomic hazards, and picking errors. Using process failure mode effects analysis (PFMEA), we identified the root causes of operational strain and established an optimized process for 21 parent parts based on the commonality and frequency of co-occurrence. This physical optimization resulted in a 36%–49% reduction in kitting times and a 30%–36% improvement in space utilization. To complement these logistical gains, the research evaluates the transition from manual paper guidance to digital interfaces, including **pick-by-light (PbL)**, overhead projection, and tangible virtual interfaces. While digital guidance systems significantly reduce picking errors and processing times, this study further analyzes their impact on **Situation Awareness (SA)** and physiological strain. The findings indicate that while PbL enhances speed, it may lead to higher heart rate strain and reduced cognitive situational awareness compared to vision-based interfaces. The proposed "Smart Kitting" framework offers a scalable, ergonomic, and high-precision solution for small-to-medium enterprises (SMEs) seeking to bridge the gap between real-world production and virtual management systems.

1. INTRODUCTION

Production-based businesses have been faced with significant challenges due to globalization, which include intense competition, limited market opportunity, increased frequency of product releases, and scale-based demand fluctuations of products [1]. In 2021, the European Commission (EU) launched the Industry 5.0 vision, which mainly deals with human centric, resilient, and sustainable systems [2]. The anthropocentric approach of production and logistics systems is essential since work does not end at design; it is vital to observe the impact of Industry 4.0 (I4.0) introduced technologies on humans and implement changes, when needed, to guarantee the successful operation of processes [3]. Due to this, smart kitting has gained popularity in recent years since, during assembly; pre-sorted kits are simple to handle as compared to line-stocking or continuous flow production [4, 5]. Kitting saves the assembly labour of the workers by removing retrieval time and minimizing assembly time when parts are found in already sorted kits [6,7].The I4.0 concept encompasses primarily enabling technologies which are Cyber-physical Systems (CPS), Internet of Things (IOT) and cloud computing. IoT is linked to interconnection of different devices that are based on sensory, communication, networking, and information processing technologies [8]. Data can be collected by sensor networks about the manufacturing process and subsequently utilize these data to optimize the process. Cloud computing can be defined as the sharing of documents, servitization, collaboration, distributed production, and optimization of resources [9].Under a smart kitting system, pickers read the parts needed and move around the storage area in a linear manner to pick the right number of parts needed by the assembler [10]. The kitting process may end up being bulky hence delayed part assembly thus may fail to meet customer demands. It is noteworthy that kitting is time consuming and will interfere with assembly in case of delay. The lack of supplies can result in picker's kit shortage, thereby lowering the efficiency and adding storage, as the kits are pre-prepared [11, 12]. In case assembling and kitting areas are distant, the kit carts are rolled to the designated kit cart location. Thus, a suitable organization of the parts has to save space in racks taking into account the size of the parts as well as containers. There should be standardization of parts according to commonality, which will greatly minimize the kitting time [13]. Mixed-model assembly typically consists of a myriad of components and it is important that the right materials be provided at the right time during the assembly process [14]. Kitting is significant in the contemporary assembly systems particularly when the products are of great variety. This will enhance efficiency and aid operators in finding the necessary components fast and this may assist in enhancing the quality of assembly. At the same time, the process presents risks, especially when preparing the kit, when errors may happen and be carried over to the assembly process, causing delays or bad builds. In general, the efficiency of kitting is determined by the control and monitoring of the preparation process to balance its operational advantages and possible costs related to quality [15]. Conclusions made were that kitting quality applies in comparison of kitting and other part feeding policy. Consequently, to effectively use kitting in the industry, it is important to minimize the kit errors and quality costs related to preparing kits. Although quality is a significant factor in contemporary logistics systems, like in the theme of Logistics 4.0, the industry is yet to agree on how to support kit quality in cases where kitting is involved. In this text, Smart Kitting system the procedure of assembling all the individual parts, subassemblies, and fasteners needed by a given work direction on a given vehicle and assembling them into a single container or trolley.it can be any type of electric vehicles or internal combustion engine. The manufacturing process of both vehicles and the part or components used in a vehicle should be merged in the body and exterior parts. The kiting system environment is defined by the components of the vehicles, the flow of materials and the flow of all the components through the kiting area and to the assembly line to their stations of origin, i.e. their storage. The smart kitting system utilizes multiple picking processes based on cost, precision and automation degree.

2. LITERATURE REVIEW

This section is divided into four parts: In the first part, research related to kit quality and kit preparation is reviewed, and shortcomings in the research literature paper purpose are highlighted. The second part is the digitalization of the system to develop a smart kitting system depending on the type of architecture. The third step is error-proofing the system and working background of it. The fourth step is checking the tracking of the material and working for it. Tables 1 and 2 collectively summarize the research context of kitting systems. Table 1 reviews the different types of kitting errors along with their causes and impacts reported in the literature. Table 2 presents a concise analysis of existing studies and highlights the proposed future work aimed at addressing current limitations and improving overall system efficiency.

Table 1. Literature Review for kitting error type

Kit error type	Description	Author
Wrong Instruments	A different instrument than required is included in the kit	Caputo, Pelagagge, and Salini, Caputo, Pelagagge, and Salini [28,29]
Missing component	A component is missing from the kit	Caputo, Pelagagge, and Salini Caputo, Pelagagge, and Salini [28,29]
Defective component	A component with damages or manufacturing errors in including in the kit.	Caputo, Pelagagge, and Salini, Caputo, Pelagagge, and Salini [28,29]
Wrong quantity	Main parts and few another parts number is to be included in the system i.e. in kit.	Caputo, Pelagagge, and Salini Caputo, Pelagagge, and Salini Brynzér and Johansson [28,29,19]
Wrong position	A Unit is positioned incorrectly within the kit.	Caputo, Pelagagge, and Salini Caputo, Pelagagge, and Salini [28,29]

Table 2. Analysis of Current Studies and Proposed Future Work in Kitting Systems

Authors (Year)	**Current Status (Conceptual Design)**	**Gap & Required Action (Smart Kitting Perspective)**
Koren (2010) [1]	Reconfigurable manufacturing enables flexible production systems	No integration with kitting To Develop adaptive smart kitting aligned with RMS
Breque et al.(2021) [2]	Industry5.0 emphasizes human-centric and sustainable manufacturing	No implementation in kitting Design human-centric smart kitting systems
Panagouet al. (2023) [3]	Human-robot interaction improves workplace collaboration	Limited application in kit Integrate cobots in smart kitting operations
Hanson & Brolin (2013) [4]	Kitting improves efficiency over line stocking in certain scenarios	Static decision-making Develop AI-based dynamic smart kitting selection
Bozer & McGinnis (1992) [5]	Fundamental framework for kitting systems	Not suitable for Industry 4.0Integrate IoT and CPS into smart kitting
Brolin et al. (2017) [7,6]	Human cognitive workload impacts assembly performance	No digital assistance Implement AR -based smart kitting support
Xu et al. (2018) [8]	Industry 4.0 technologies enable smart manufacturing	No direct kitting application Apply IoT and CPS in smart kitting systems
Moeuf et al. (2018) [9]	Industry 4.0 adoption challenges in SMEs	High-cost barrier Develop cost effective smart kitting solutions
Khajavi et al. (2018) [10]	Model-based kitting used in additive manufacturing	Limited scope Extend to EV and mixed-model smart kitting systems
Fansuri et al. (2017) [11]	Lean kitting improves efficiency but faces implementation issues	No digital integration Combine lean with digital twin-based smart kitting
Kovacs (2020) [12]	Facility layout optimization improves efficiency	Static layouts Develop real-time adaptive layouts for smart kitting

Hanson et al. (2017) [13]	AR supports picking operations in kitting	Limited scalability Integrate AR with IoT-enabled smart kitting
Winkel Haus & Grosse (2020) [14]	Logistics 4.0 enables smart material flow	No direct kitting integration Develop smart logistics-kitting architecture
Caputo et al. (2020)[23]	Comparison of manual and automated kitting systems	No predictive optimization Apply AI-based cost and performance optimization
Wang et al. (2015) [20]	Cyber-physical systems enable smart manufacturing integration	Not applied to kitting Develop CPS-enabled smart kitting framework
Lee et al. (2015) [21]	CPS architecture supports Industr 4.0 systems	No human-centric focus Integrate Industry 5.0 concepts in smart kitting
Gubbi et al. (2013) [22]	IoT enables real-time monitoring	No kitting application Implement IoT-based inventory tracking in kitting
Harrison (2019) [25]	Integration of automation and logistics systems	Lack of synchronization Use digital twin for smart kitting coordination

From the literature review, it is observed that existing kitting systems are largely static and lack integration with real-time technologies such as IoT, CPS, and AI. Additionally, the human-centric aspects of Industry 5.0 were not fully incorporated.

3. PROBLEM STATEMENT

Therefore, there is a need to develop a smart kitting system that is adaptive, data-driven, and suitable for high variability environments such as EV manufacturing.

3.1 OBJECTIVES

- ➢ The operational efficiency can be improved by reducing the assembly cycle time and increasing the overall vehicle production throughput on the assembly line.
- ➢ Enhance quality and error prevention using Poka-Yoke mechanisms to minimize assembly errors and ensure correct part usage.
- ➢ Optimizing material flow and inventory management through real-time part tracking and controlled kitting at each station.
- ➢ Enable vehicle and station traceability by tracking VC numbers across assembly stations through proper system implementation and documentation.

4.0 EXISTING METHODOLOGY

TRADITIONAL AND AUTOMATED KITTING MODELS

Kitting is a frequently adopted method for feeding parts from warehouses to assembly lines, allowing minimization of space occupation and work-in-process holding costs while simplifying material flow and supporting manual assembly. However, traditional manual kitting preparation incurs high workforce costs. A comprehensive cost model was developed that enables a quantitative comparison between manual and automated kitting systems, demonstrating that automation-assisted kitting can be economically competitive with manual approaches when accounting for capital investment, workforce costs, space occupation, and quality expenses [26,20].

5.0 Proposed Smart Kitting Methodology

The proposed smart kitting system development includes the following processes:

1) Manual kitting
2) Pick by light (PTL) system
3) Pick by paper (Traditional Method)
4) Automated Kitting System
5) Zone based Kitting
6) Batch Kitting
7) Just in Sequence (JIS)
8) Just in Time (JIT)
9) Lineside Inventory
10) Bill of Materials (BOM)
11) Poka-Yoke (Error Proofing)

The above concepts represent the fundamental principles of lean manufacturing and smart kitting systems, focusing on efficient material flow, inventory reduction, and error-proof assembly operations in modern production environments.

Key Concepts in Smart Kitting and Lean Manufacturing Systems

Smart kitting systems are built on the fundamental principles of lean manufacturing, material handling, and error-proofing techniques. These concepts enable efficient material flow, reduce inventory, and improve accuracy in Industry 4.0-based manufacturing environments.

Manual kitting is a conventional approach in which operators manually collect components using a predefined pick list. Although it offers flexibility and low implementation cost, it is less efficient and more prone to human error than automated systems [17].

Pick-by-light (PTL) systems are widely used in smart kitting environments to improve picking accuracy and speed. These systems use visual indicators to guide operators to the correct storage locations and quantities, thereby reducing errors and improving productivity [19].In contrast, pick-by-paper methods rely on printed lists, which lack real-time tracking and increase the likelihood of mistakes, making them less suitable for modern manufacturing systems [18].

Automated kitting systems integrate robotics, conveyors, and automated storage and retrieval systems (ASRS) to perform kitting operations with minimal human intervention. These systems are typically controlled by centralized computer systems, which enable real-time tracking and high operational efficiency [22]. Additionally, zone-based kitting divides the warehouse into specific areas, allowing operators to focus on designated zones, thereby reducing travel time and improving efficiency [18]. Batch kitting further enhances productivity by allowing multiple kits to be prepared simultaneously through bulk picking and subsequent sorting [17].

Just-in-time (JIT) and just-in-sequence (JIS) are critical lean manufacturing principles applied in kitting systems. JIT focuses on delivering components only when required, minimizing inventory and reducing waste, while JIS ensures that parts are delivered in the exact sequence of assembly operations, which is particularly important in automotive manufacturing [18, 19].

The lineside inventory represents the traditional method of storing large quantities of components near the assembly line. Although it ensures availability, it leads to clutter, increased space usage and inefficiencies. Smart kitting systems aim to replace lineside inventory with pre-arranged kits, thereby improving workspace organization and reducing search times [17].

The **Bill of Materials (BOM)** plays a crucial role in smart kitting systems by providing a structured list of components required for product assembly. Modern kitting systems use digital BOM data integrated with centralized computer systems to generate accurate pick lists for each kit [22].

ERROR-PROOFING TECHNIQUES SUCH AS POKA-YOKE,

Introduced by Shigeo Shingo, these are essential for ensuring quality in kitting systems. These techniques prevent incorrect part selection and reduce defects by incorporating validation mechanisms, such as sensors and alerts [17]. Furthermore, pick-to-light systems integrated with IoT and RFID technologies enable real-time monitoring and tracking, significantly improving accuracy and operational efficiency in smart kitting environments [23,24].
Overall, the integration of these concepts forms the foundation of smart kitting systems, enabling efficient material handling, reduced inventory, enhanced accuracy, and improved productivity in modern manufacturing systems [25]
The main objective of this study is to introduce a smart kitting system with an increase in operational efficiency and cycle time reduction in the assembly line. Quality and error-proofing, material Flow and Inventory Management.

Smart Kitting System Architecture

The Smart Kitting System Architecture (Figure 1) includes data planning and system design, implementation of error-proof kitting operations, integration with the assembly line through JIS delivery, and evaluation of overall system performance.

1. Planning and Data Core

- The system is centralized around the **MES/BOM database and main server**, which stores the product structure and production sequence (VIN-based).
- Real-time production data are distributed through the **OT network**, ensuring synchronized communication across all system components.
- Provides variant-specific information required for accurate kitting and sequencing of the target regions.

2. Error-Proof Kitting Execution

- The kitting **supermarket layer** executes component picking based on the MES-driven instructions.
- **Tablet devices** display sequenced pick lists for each kit, thereby improving operator guidance.
- **E-scan devices** perform real-time validation of components through barcode/RFID scanning.

- Ensures **Poka-Yoke (error-proofing)** by verifying the correct part selection before kit completion.

3. Assembly Line Integration (JIS Delivery)

- Network connectivity via gateways enables seamless integration between kitting and assembly lines.
- **Zone PCs** at the assembly stations receive synchronized production sequence data.
- Displays variant**-specific digital work instructions** aligned with incoming kits.
- Supports Just**-In-Sequence (JIS)** delivery, reducing search time, and improving assembly accuracy.

4. System Outcome

- Enables Just**-In-Time (JIT)** and Just**-In-Sequence (JIS)** material flow
- Improves picking **accuracy and traceability**
- Reduces human **errors and line-side delays**
- Enhances overall **production efficiency and quality control**

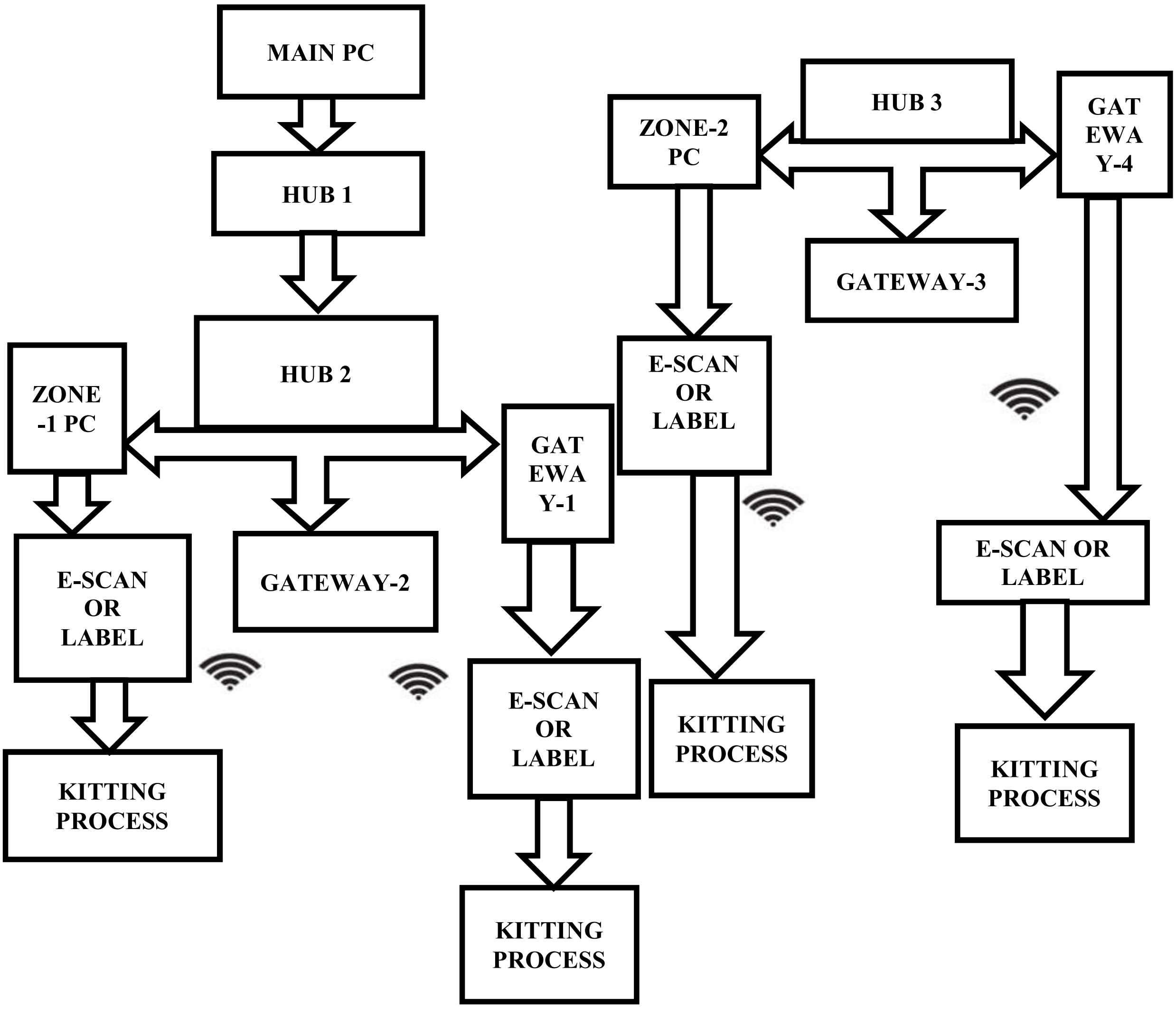

Fig1: Flow Diagram of Central Kitting

5.2 SMART KITTING SYSTEM INTEGRATION

The figure 2 shows smart kitting integration and Core System Modules, Real-Time Operation and Feedback.

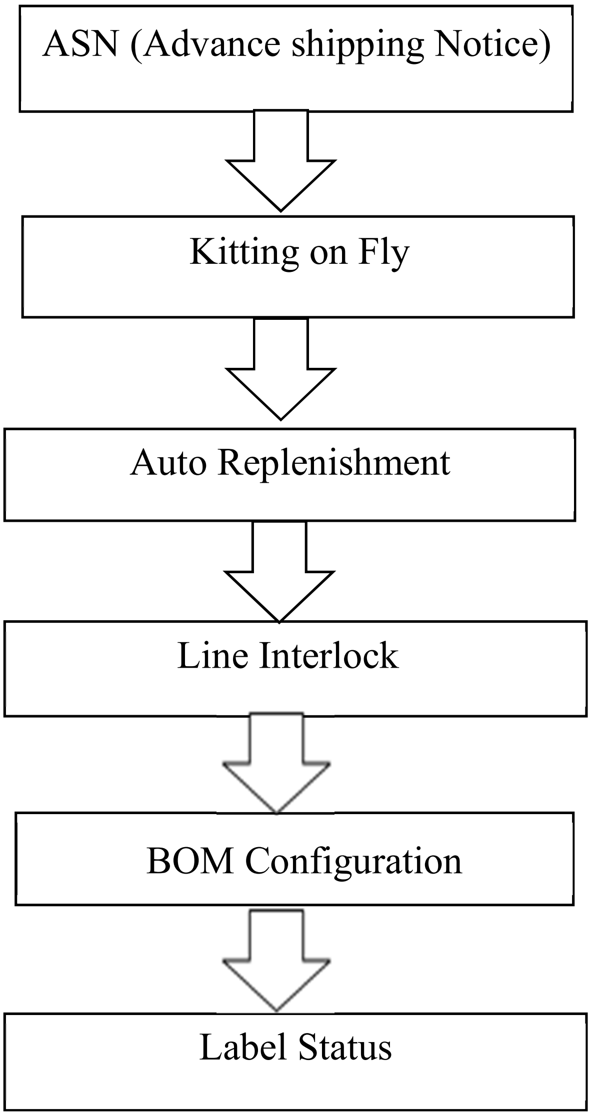

Fig2: Smart Kitting System Integration

A. Core System Modules

The Smart Kitting system consists of six functional modules that enable efficient kitting operations:

- **Kitting on Fly enables** dynamic kit generation based on real-time production changes and variant-specific BOM updates. This supports flexibility in handling demand variability and in engineering changes.
- **Auto Replenishment implements** just-in-time (JIT) material supply by monitoring line-side inventory using sensors or E-Kanban signals. It automatically triggers replenishment to prevent stock-outs and reduce waiting time.
- **Line Interface** Acts as a communication layer between the SKS and the assembly line systems. It provides real-time sequencing information, ensuring synchronization with production schedules.
- **BOM Configurator** Maintains and updates product-specific BOM data for different vehicle variants. It ensures accurate component selection and supports error-proofing (Poka-Yoke).
- **Label Status** Manages barcode/RFID-based labelling of parts and kits. It enables traceability and verification during picking and delivery operations.
- **Admin Control** Provides system-level management including user access, configuration, and monitoring. It ensures system security and operational control.

Real-Time Operation and Feedback

- **Live Data Monitoring:** Continuous tracking of system transactions, inventory status, and operational logs improves transparency and diagnostics.
- **Status Indicators:** Real-time workflow updates (e.g., completion of scheduled kits) ensure process visibility and operational efficiency.
- **QR Code-Based Validation:** Supports scanning for task confirmation, material verification, and delivery validation, thereby reducing human errors.
- **Network and Access Monitoring:** Ensures reliable communication between devices such as scanners, pick-to-light systems, and control units.

Operational Outcome

- Real-time, demand-driven kitting
- Reduction in material handling errors
- Improved synchronization with assembly line take time
- Enhanced traceability and quality control

6.0 Flow chart of developed algorithm

The figure 3 shows that the flow chart of developed algorithm and real time acquisition.

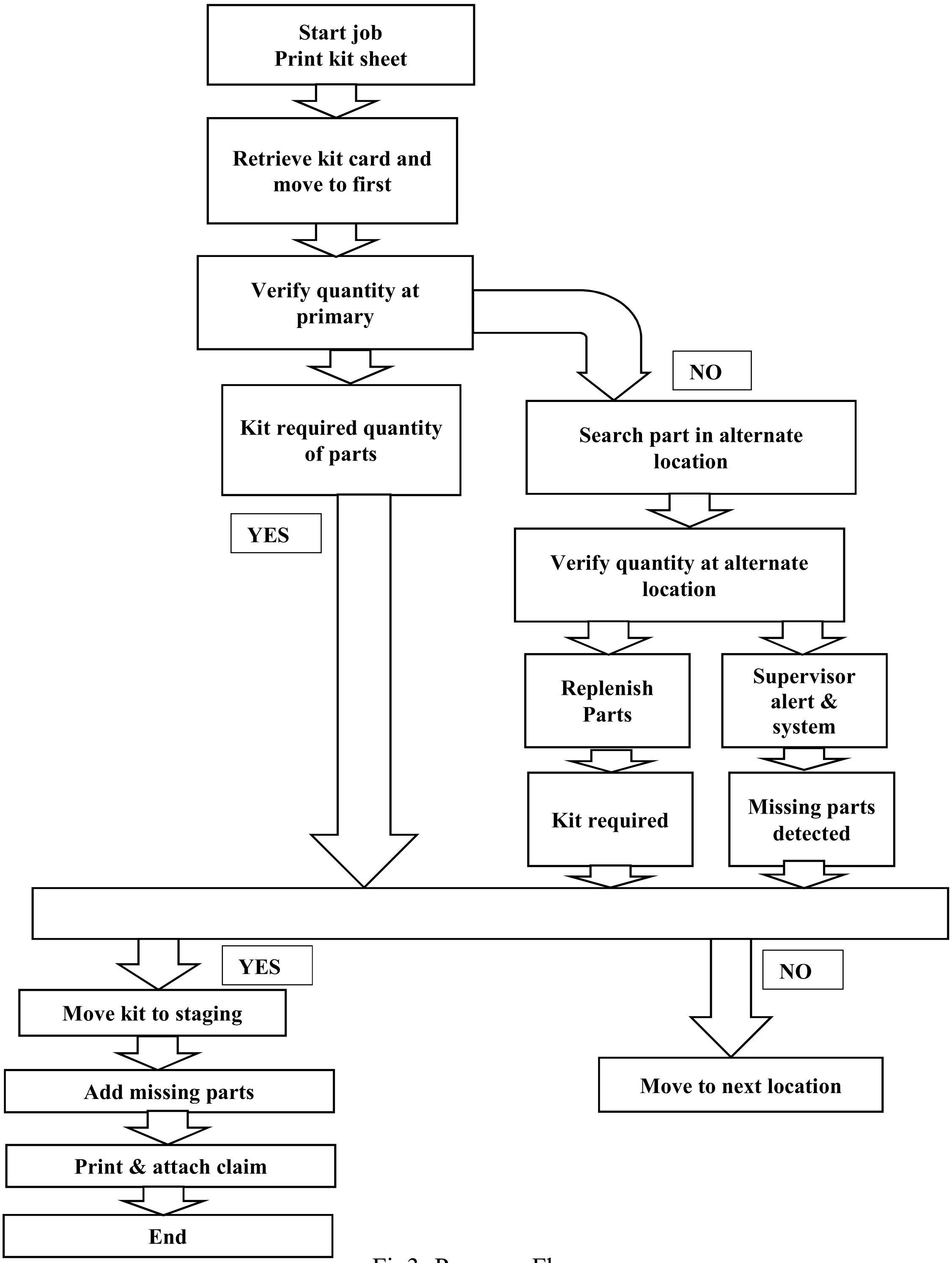

Fig3: Program Flow

The proposed system utilizes a Python-based architecture to enable real-time data acquisition, processing, and control for smart kitting in an industry framework. The program initializes communication with IoT devices and databases, followed by continuous data collection from RFID-enabled bins, workstations, and material handling systems to track SMT kits and work-in-process inventories. The collected data were pre-processed and stored for analysis.

Rule-based and data-driven algorithms are applied to monitor inventory levels, detect shortages, and prioritize the kitting tasks. Based on these decisions, automated actions such as resource allocation and material dispatch are executed by the system. Performance metrics are continuously evaluated to support adaptive control, whereas exception handling ensures system reliability. The processed data are visualized through dashboards, enabling improved efficiency, accuracy, and responsiveness in manufacturing operations.

7.0 Results and discussion

Table 3 and Figure 4 present a comparative review of pre- and post-implementation performance of the Smart Kitting System, highlighting improvements in accuracy, time efficiency, line stoppages, search time, and error throughput.

Table 3. Literature Review for Before vs After Smart Kitting System

Parameter	Conventional Kitting	Smart Kitting System (SKS)	Improvement (%)
Picking Accuracy (%)	92	99	+7.6%
Average Picking Time (sec/kit)	180	120	−33.3%
Line Stoppage (min/shift)	25	8	−68%
Inventory Stock-outs (per day)	6	1	−83%
Operator Search Time (sec)	40	10	−75%
Error Rate (%)	8	1	−87.5%
Throughput (kits/hour)	20	32	+60%

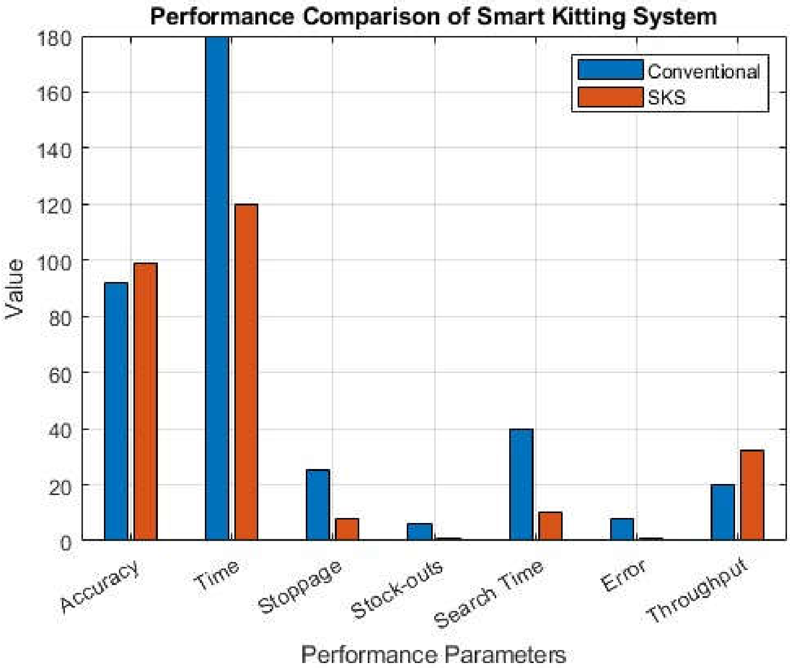

Figure4. Performance comparison of SKS (Accuracy, Time, Stoppage, search time, error throughput)

The proposed Smart Kitting System (SKS) demonstrates a significant improvement over conventional kitting approaches by integrating real-time data processing, automated replenishment, and error proofing. The results indicate that the implementation of SKS enhances picking accuracy from 92% to 99%, while reducing error rates by approximately 87.5%. Additionally, the average picking and operator search times were reduced by 33.3% and 75%, respectively, leading to improved operational efficiency.

The system also minimizes line stoppages and inventory stock-outs, thereby ensuring an uninterrupted material flow and better synchronization with assembly line operations. The integration of MES, IoT-enabled tracking, and Poka-Yoke validation contributes to improved traceability and quality control.

Overall, the SKS enables the effective realization of Just-In-Time (JIT) and Just-In-Sequence (JIS) principles, making it highly suitable for high-variability manufacturing environments, such as vehicle assembly systems. Future work should focus on integrating artificial intelligence and digital twin models for predictive optimization and further performance enhancement.

Table 4 and Figure 5 collectively present a comparative analysis of time demand and operator performance before and after optimization, demonstrating a significant reduction in task completion time and improved operational efficiency following the implementation of the proposed measures.

Table 4. Comparative analysis of the time demand after implementation of measures

	Time demand before (s)	Time demand after measures (s)	Saved time (s)
Operator 1	159	15	144
Operator 2	140	19	121
Operator 3	125	10	115
Operator 4	168	13	155
Operator 5	148	20	128
Total	740	77	663

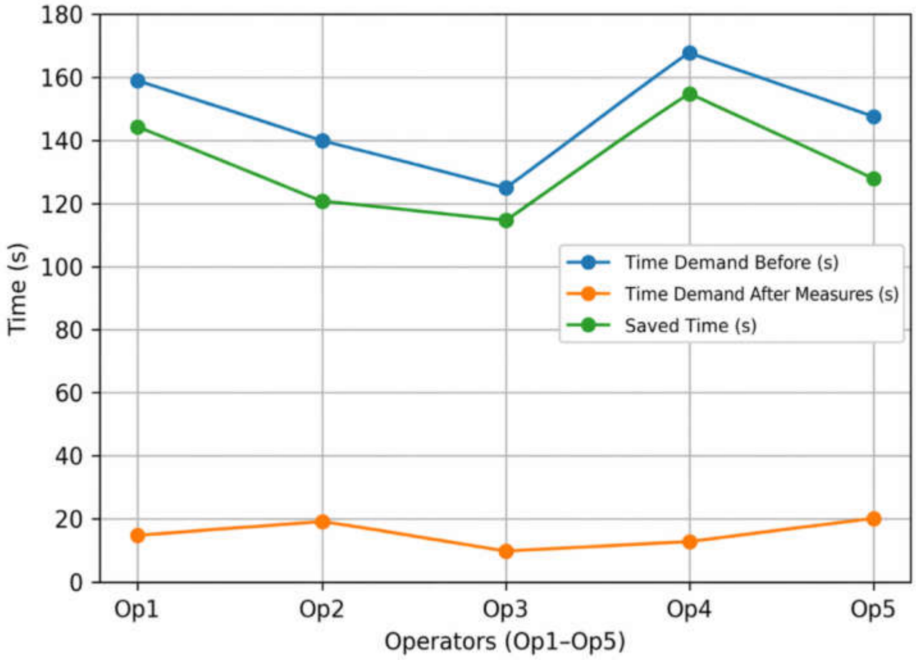

Fig 5. Before and after optimization , operators

The results indicate a substantial reduction in time (sec) required by operators after implementing the proposed kitting optimization strategy. The maximum time reduction was observed for Operator 4, where the time decreased from 160 s to 9s, resulting in a saving of 151 s. Overall, the total time demand was reduced from 736 s to 54s, achieving a cumulative saving of 682 s. This demonstrates the effectiveness of structured kitting and line-side material organization in minimizing the non-value-added activities.

SMART KITTNG SYSTEM

The implementation of the Smart Kitting system shows potential improvements in picking accuracy, reduction in line stoppages, and enhanced synchronization efficiency, which can be further validated through experimental or simulation-based analysis. And Figure 6 shows output Visualization of the Proposed Smart Kitting System

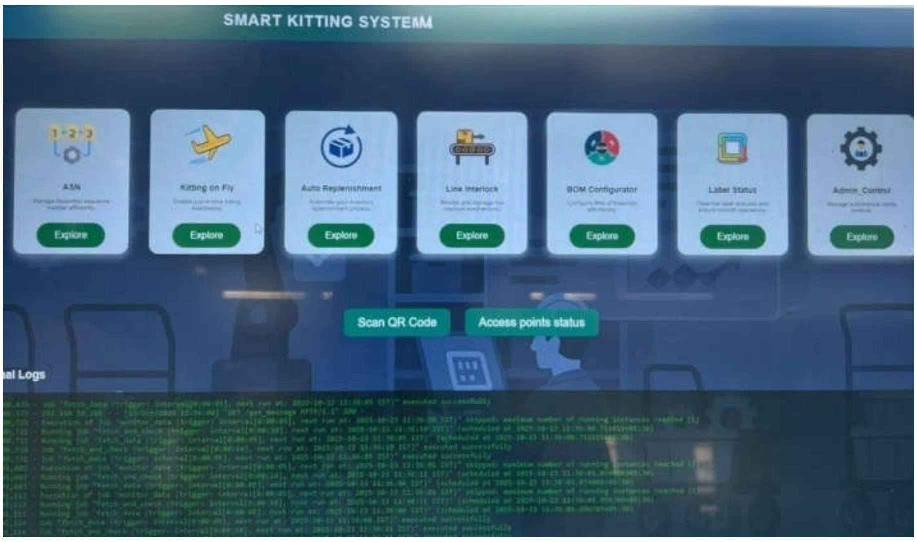

Fig 6. Smart kitting system

CONCLUSION

The proposed Smart Kitting System (SKS) shows a significant improvement of traditional kitting strategies by including real-time data processing, automated replenishment, and error-proofing systems into the assembly processes. These findings are unequivocal that SKS is a significant improvement to the system especially regarding accuracy, efficiency, and reliability of operation. The picking accuracy was significantly improved as it was found to have improved to 99, and the error rates decreased to about 87.5%. This underscores the usefulness of the established Poka-Yoke systems and checking procedures in the reduction of human errors in part selection. Also, the 33.3 per cent and 75 per cent decrease in the average picking time and operator search time, respectively, in the system proves that the system successfully eradicates non-value-added operations and simplifies material-handling operations. The time-efficiency point of view is that the introduction of SKS led to a significant reduction in total time spent to execute the tasks by all the operators. The cumulative savings was 682 s as the total time demand decreased by 736 to 54 s. Individual improvements were the greatest in Operator 4, where it went down to 9 s after having been 160 s. The fact that these improvements are consistent between different operators illustrates that the system is resilient, scalable and not dependent on operator variability. Moreover, more efficient traceability, inventory visibility, and synchronization with the assembly lines operation is guaranteed by the integration of Manufacturing Execution Systems (MES), IoT-based tracking, and real-time monitoring. The system can reduce the line stoppages and stock-outs successfully, thus, increasing the stability of the whole production process with the continuous flow of materials. The results also affirm that SKS facilitates the practical implementation of Just-in-Time (JIT) and Just-in-Sequence (JIS) concepts, which makes it very adequate in high variability manufacturing processes including automotive assembly lines, including ICE, electric and future vehicle platforms. The system will help to enhance the responsiveness and complexity of operations through matching the demand of producing with the delivery of the material. To sum up, the Smart Kitting System may be regarded as one of the enablers of modern manufacturing systems, providing some quantifiable changes in accuracy, efficiency, and reliability of the processes. Its combination with digital technologies makes it a scalable solution of next generation assembly environments. To allow predictive optimization, adaptive decision-making, and additional system performance improvement under dynamic production conditions, future research may be centered on the implementation of artificial intelligence and digital twin frameworks.

FUTURE SCOPE

Smart Kitting and IoT Integration

- IoT Future systems used in real-time kitting intelligence can combine the use of advanced internet of things enabled work boards with predictive analytics to dynamically track the kits and WIP of SMT, enhancing decision making eliminating bottlenecks.
- AI-based demand forecasting and scheduling . The integration of IoT data and machine learning models can facilitate the correct demand forecast, adaptive human resource planning, and efficient production planning in kitting work.
- Autonomous material handling system Integration Wider integration of AMRs and AGVs with IoT platforms have the potential to further advance the real-time flow of materials, decrease manualization, and enhance the effectiveness of line-side delivery.
- Digital twin of kitting operations Simulation Digital twins can be developed to simulate kitting processes, find inefficiencies, and be used to optimize real-time distributed warehousing systems.
- Edge computing to achieve better reaction speed Edge-based IoT architectures can minimize reaction time delays in information processing and, thus, react more rapidly to changing manufacturing settings.
- Improved inventory visibility and control RFID and sensor-based tracking can be used to provide near-zero inventory misalignment and enhanced traceability of distributed kitting sites in future systems.
- Human-machine cooperation (Industry 5.0 direction) the combination of collaborative robots (cobots) and IoT-based kitting systems can be used to enhance ergonomics, decrease the workload of operators, and increase productivity.
- Scalability and system design Modularity Modular system design will enable easy scaling of individual production lines and factories.

REFERENCES

[1] Koren, Y. The Global Manufacturing Revolution: Product-Process-Business Integration and Reconfigurable Systems; John Wiley & Sons: New York, NY, USA, 2010.

[2] European Commission, Directorate-General for Research and Innovation, Breque, M., De Nul, L., Petridis, A. 2021. "Industry 5.0: Towards A Sustainable, Human-Centric and Resilient European Industry." Publications Office of the European Union. http://data.europa.eu/doi/10.2777/308407.

[3] Panagou, Sotirios, W. Patrick Neumann, and Fabio Fruggiero. 2023. "A Scoping Review of Human Robot Interaction Research Towards Industry 5.0 Human-Centric Work places." International Journal of Production Research 62 (3): 974–990. https://doi.org/10.1080/00207543.2023.2172473.

[4] Hanson, Robin, and Anna Brolin. "A comparison of kitting and continuous supply in in-plant materials supply. "International Journal of Production Research 51, no. 4 (2013): 979-992.

[5] Bozer, Yavuz A., and Leon F. McGinnis. "Kitting versus line stocking: A conceptual framework and a descriptive model. "International Journal of Production Economics 28, no. 1 (1992): 1-19.

[6] Brolin, Anna, Peter Thorvald, and Keith Case. "Experimental study of cognitive aspects affecting human performance in manual assembly. "Production & Manufacturing Research 5, no. 1 (2017): 141-163.

[7] Brolin, A., G. Bäckstrand, D. Högberg, and K. Case. "Inadequately designed information and its effects on the cognitive workload." In Proceedings of the 28th International Manufacturing Conference (IMC), pp. 121-129. 2011.

[8] Xu, L.D.; Xu, E.L.; Li, L. Industry 4.0: State of the art and future trends. Int. J. Prod. Res. 2018, 56, 2941–2962.

[9] Moeuf, A.; Pellerin, R.; Lamouri, S.; Tamayo-Giraldo, S.; Barbaray, R. The industrial management of SMEs in the era of Industry 4.0. Int. J. Prod. Res. 2018, 56, 1118–1136.

[10] Khajavi, Siavash H., Martin Baumers, Jan Holmström, Ender Özcan, Jason Atkin, Warren Jackson, and Wenwen Li. "To kit or not to kit: Analysing the value of model-based kitting for additive manufacturing." Computers in Industry 98 (2018): 100-117.

[11] Fansuri, A. F. H., A. N. M. Rose, NMZ Nik Mohamed, and H. Ahmad. "The challenges of lean manufacturing implementation in kitting assembly." In IOP Conference Series: Materials Science and Engineering, vol. 257, no. 1, p. 012069. IOP Publishing, 2017.

[12] Kovacs, g. 2020. "Combination of lean value-oriented conception and facility layout design for even more significant efficiency improvement and cost reduction. "International Journal of production Research. doi:10.1080/00207543.20201712490.

[13] Hanson, R., W. Falkenström, and M. Miettinen. 2017. "Augmented Reality as a Means of Conveying Picking Information in kit Preparation for Mixed-Model Assembly." Computers and Industrial Engineering 113: 570–575.

[14] Winkelhaus,S., and E.H. Grosse.2020. "Logistics4.0: a Systematic Review Towards a new Logistics System." International Journal of Production Research 58 (1): 18–43.

[15] Bozer, Y. A.; McGinnis, L. F. Kitting versus line stocking: A conceptual framework and a descriptive model; International Journal of Production Economics, 1992.

[16] Hanson, R.; Brolin, A. A comparison of kitting and continuous supply in in-plant materials supply; International Journal of Production Research, 2013.

[17] Brynzér, H.; Johansson, M. I. *Design and performance of kitting and order picking systems*; International Journal of Production Economics, 1995.
[18] Caputo, S.; Pelagagge, P. M. *RFID* application in inventory control and production systems; International Journal of Production Economics, 2011.
[19] Limère, V.; Van Landeghem, H.; Goetschalckx, M. *Optimizing part feeding in assembly lines: Kitting versus line stocking;* International Journal of Production Economics, 2015.
[20] Wang, L.; Törngren, M.; Onori, M. Current status and advancement of cyber-physical systems in manufacturing; Journal of Manufacturing Systems, 2015.
[21] Lee, J.; Bagheri, B.; Kao, H. A. A cyber-physical systems architecture for Industry 4.0-based manufacturing systems; Manufacturing Letters, 2015.
[22] Gubbi, J.; Buyya, R.; Marusic, S.; Palaniswami, M. Internet of Things (IoT): A vision, architectural elements, and future directions; Future Generation Computer Systems, 2013.
[23] Koren, Y. The Global Manufacturing Revolution: Product-Process-Business Integration and Reconfigurable Systems; John Wiley & Sons: New York, NY, USA, 2010.
[24] A. C. Caputo, P. M. Pelagagge, and P. Salini, “A model for planning and economic comparison of manual and automated kitting systems,” International Journal of Production Research, Jan. 2020, https://doi: 10.1080/00207543.2020.1711985.
[25] R. Harrison, “Dynamically Integrating Manufacturing Automation with Logistics,” IEEE International Conference on Emerging Technologies and Factory Automation, Sep. 2019, https://doi: 10.1109/ETFA.2019.8869405.
[26] Caputo, A.C., P.M. Pelagagge, and P. Salini.24 “Modelling Human Errors and Quality Issues in Kitting Processes for Assembly Lines Feeding.” Computers and Industrial Engineering 111: 492–506.
[27] Caputo, A.C., P.M. Pelagagge, and P. Salini.2017c. “A criticality Analysis of Kitting Processes,” Proceedings of the Italian Industrial Systems Engineering Summer School Francesco Turco, 13–15 September, Palermo, Italy.