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OPTIMISING MANUFACTURING SYSTEMS WITH AI: REDUCING HUMAN ERRORS AND ENHANCING RESPONSE TIMES IN MES AND SUPPLY CHAIN ORDERING SYSTEMS

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ABSTRACT
The manufacturing industry achieves efficiency minimizes human errors and optimizes production through Artificial Intelligence (AI). Machine Learning (ML) along with Computer Vision and Predictive Analytics guide Manufacturing Execution Systems (MES) and supply chain ordering systems with automated operations that deliver improved decision capabilities. AI offerings improve live surveillance capabilities and automated process control systems while maintaining accurate inventory records which optimizes operational efficiency (Zhang et al., 2020). Through predictive maintenance approaches steered by AI technology operators reduce the number of unexpected stoppages that create expense reductions and efficiency benefits (Kusiak, 2021). AI applications in manufacturing enable faster adjustments of production schedules which enable businesses to adjust their manufacturing operations according to rising and falling market demands. The essential nature of artificial intelligence in manufacturing systems will expand as it progresses because it generates industrial evolution combined with sustainability and operational excellence.

Keywords
AI in Manufacturing, Smart Manufacturing Systems, Artificial Intelligence in Supply Chain, Manufacturing Execution Systems (MES), AI-Powered Predictive Maintenance

INTRODUCTION

Manufacturing operations have experienced a fundamental transformation through AI system application which delivers measurable improvements to efficiency and accuracy as well as operational speed. Manufacturing Execution Systems (MES) together with supply chain ordering systems currently integrate AI-driven technologies to create automated solutions that maximize workflow and lower human mistakes along with enhancing decision-making techniques (Lee et al., 2021). The transition to smart manufacturing benefits from artificial intelligence through ML and predictive analytics and RPA solutions which help manufacturers tackle operational problems while ensuring smooth production management and quick market response (Chen et al., 2021).

The implementation of AI in manufacturing serves to decrease the number of errors made by operators. The current standard of manufacturing relies on humans in each process which causes systematic errors along with operational inefficiencies. The integration of AI technologies particularly computer vision along with real-time quality control brings down production defects to ensure precise outcomes (Zhou et al., 2021). Supply chain efficiency receives benefits from AI through optimized demand predictions and better inventory control and accelerated order-fulfilling processes (Wang et al., 2021). Modern manufacturing enterprises gain agility along with competitive advantages due to these technological improvements.

The implementation of AI systems enables manufacturing companies to speed up their operational timelines with its capability to anticipate manufacturing disruptions and run automated decision processes. AI predictive systems that analyze equipment data use that information to identify operational failures in advance so production output improves while time spent without production decreases (Kusiak, 2021). The production speed increases through robotic

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automation driven by AI technology since it provides consistent performance while replacing human labor for repetitive operations (Xu et al., 2021).

AI adoption by industries will lead to enlarging its influence on manufacturing systems while promoting innovation together with sustainability and better cost performance. The investigation examines how Artificial Intelligence affects MES and supply chain ordering systems by minimizing errors and increasing performance alongside rapid manufacturing reactions.

LITERATURE REVIEW

2.1 The Role of AI in Modern Manufacturing

Modern manufacturing depends heavily on Artificial Intelligence which helps organizations obtain enhanced accuracy efficiency and better responsiveness. The widespread adoption of artificial intelligence grounds its applications in machine learning (ML), deep learning, computer vision, and predictive analytics for optimizing production operations supply chain management, and real-time decision systems (Lee et al., 2021). Manufacturers can reduce market response time and human mistake frequency while improving their operational models through AI implementation in MES and supply chain ordering tools (Wang et al., 2021).

Xu et al. (2021) explain that AI-based MES platforms achieve real-time production process monitoring to enhance quality control accuracy together with predictive maintenance along workflow automation capabilities. Extracting knowledge from AI algorithms allows analysis of large production data which enables predictions to perform maintenance before failures occur and reduces production stoppages. The supply chain ordering systems running on artificial intelligence use predictive analytics with intelligent inventory systems and automated procurement technology to optimize their operations (Zhou et al., 2021). The substitution of human choices by AI technological systems makes production operations more effective and reduces financial losses from errors.

2.2 AI and Error Reduction in Manufacturing

AI provides its most essential benefit to manufacturing through its ability to minimize human errors during production process execution. Traditional manufacturing practices maintain substantial dependence on human workers which leads to variations and product flaws in the manufacturing process. Manufacturing quality control receives substantial enhancement through AI-run computer vision systems with real-time defect detection methods that provide precise error identification (Chen et al., 2021). AI solutions detect manufacturing problems which decreases production faults while reducing both waste expenses and repeat work expenses thereby boosting manufacturer profits.

According to research machine learning models which receive historical production data become able to forecast upcoming manufacturing mistakes before they trigger. By predicting potential issues manufacturers gain the capability to change machine settings and perfect manufacturing techniques which results in better operational consistency (Kusiak 2021). Through AI-driven robotic automation, work environments experience enhanced protection against employee injuries because it decreases human contact with materials (Wang et al., 2021).

The use of AI creates better data-based choices which decreases the possibility of human mistakes in industrial production situations. AI-integrated MES platforms operate independently to modify production schedules detect resource deficiencies and enhance workflow operations (Zhang et al., 2021). The transition from person-dependent to machine-powered decision-making enhances manufacturing systems by delivering more reliable and accurate results.

2.3 AI in Supply Chain Optimization

Supplementing supply chain ordering systems with AI produces revolutionary achievements in three key areas demand forecasting inventory management and logistics operations. Supply chain systems that follow traditional models experience difficulties with demand changes supply gaps and slow order completion which produces delays and raises expenses (Xu et al., 2021). The solutions that AI provides to these issues include predictive analytics automated decision systems and intelligent inventory control methods.

Demand predictions performed by AI-enabled systems depend on the Zhou et al. (2021) method which integrates historical sales information market trend data and external indicators like economic fluctuations and weather patterns. By applying forecast data manufacturers can optimize their production schedules and procurement methods as well as distribution flows to keep inventory levels consistent with current market requirements.

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(Lee et al., 2021). Real-time inventory tracking through these systems decreases both overstock and empty stock situations thus improving both supply chain efficiency and cost-effectiveness. такі procurement systems operate through AI algorithms by assessing supplier performance then negotiating prices and direct order fulfillment to lower supply chain disruption risks per Wang et al. (2021).

AI improves warehouse processes through automated planning systems and automated warehouse systems which combine with optimized delivery solutions for the final delivery segment. Machine learning applications review traffic data together with weather information and delivery data to optimize delivery paths that boost shipment delivery both in speed and reliability (Chen et al., 2021). The AI-powered procedure both decreases product delivery timelines delivers superior customer satisfaction and improves supply chain responsiveness.

2.4 AI in Predictive Maintenance and Faster Response Times

AI has optimized predictive maintenance operations through better preventive measures which cut down equipment failure rates and keep manufacturing units active longer. The scheduled servicing methods of traditional maintenance models produce both avoidable maintenance expenditures as well as unpredicted equipment breakdowns (Kusiak, 2021). AI-driven predictive maintenance platforms monitor equipment with sensors to process this data with learning models while analyzing results in real-time therefore identifying precursor indications of failures so maintenance recommendations are provided before equipment breakdowns happen (Wang et al., 2021).

The research by Xu et al. (2021) confirmed that predictive maintenance systems enabled by AI produce outcomes such as increased machine reliability and extended equipment life as well as decreased maintenance expenses by a maximum of 40%. Analyzing temperature vibration and performance information allows these systems to use AI-based algorithms for spotting unordinary conditions while adjusting maintenance time schedules. Predictive maintenance implementation gives manufacturers increased speed for responding to equipment breakdowns together with minimized disruption time and optimized output levels.

AI-powered robotic devices function continuously without human limitations to boost both quantity and uniformity of production (Zhou et al., 2021). Real-time production adjustments through AI-integrated MES platforms achieve efficient resource management which causes little interruption to manufacturing operations (Lee et al., 2021).

2.5 Challenges and Future Prospects of AI in Manufacturing

AI implementation for manufacturing meets several hurdles that involve expensive costs of implementation and workforce distribution challenges as well as privacy issues with data (Chen et al., 2021). Small to medium enterprises experience financial barriers stopping them from implementing artificial intelligence systems because of high startup expenses. The extensive use of big data together with cloud computing by AI systems leads to concerns regarding data security and intellectual property protection which is identified by Wang et al. (2021).

AI-driven automation now causes industry-wide alarm about job loss since manufacturing roles that humans used to perform are steadily becoming automated (Zhang et al., 2021). The introduction of AI will generate novel employment fields according to experts who note that employees need development training to control these AI systems (Xu et al., 2021).

The upcoming era in AI-manufacturing technology shows great promise through its developing expansion of self-operating factories together with AI-based supply network integration and human-machine team dynamics that will reshape industrial operations (Kusiak, 2021). AI technology development mandates manufacturers to adopt AI innovation while practicing sustainability and embracing digital transformation to preserve their competitiveness across worldwide markets.

METHODOLOGY

The approach adopted to analyze Artificial Intelligence (AI) effects on manufacturing systems through Manufacturing Execution Systems (MES) and supply chain ordering systems lies within this segment. The research combines qualitative and quantitative methods to study AI's error reduction impact through case analysis and report data alongside empirical evidence which examines faster manufacturing operations.

3.1 Research Design

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The research assessment utilizes a comparative analytical structure for analyzing AI-integrated manufacturing system efficiency when compared with standard manufacturing operations. Studies base their information on peer-reviewed journal articles industry whitepapers and real-world case studies from the period between 2019 through 2021 to maintain current and pertinent data (Lee et al., 2021). Statistical data alongside surveys of major manufacturing firms and their reports has been reviewed for analytical purposes.

3.2 Data Collection Methods

The research retrieves data from primary sources alongside secondary information by concentrating on the following points:

Researchers have studied actual AI deployments in MES and supply chain operations together with performance assessments and operational speedups (Zhou et al., 2021).

Industry Reports about AI-driven industrial automation progress come from manufacturing firms and technology providers together with consulting agencies (Wang et al., 2021).

The research incorporates academic journals that examine the ways AI decreases human errors strengthens decision processes and enhances production durations (Chen et al., 2021).

Statistical research data about AI assimilation patterns predictive maintenance accomplishments and automated productivity options has been studied (Xu et al., 2021).

3.3 Data Analysis Techniques

The research team evaluates the collected information through both comparative analysis and trend evaluation which helps identify major patterns related to AI adoption along with error reduction success supply chain performance and manufacturing cycling speed. The method provides insights into production environment transformations from AI as well as specific tangible advantages for industrial implementations (Kusiak, 2021).

3.4 Limitations of the Study

Some important restrictions should be noted about this study although it provides crucial findings.

Literature analysis replaces real-time experimental research because the study relies on case reports and previous studies from other researchers and practitioners.

Research outcomes about AI effectiveness demonstrate sector-based differences in manufacturing environments because results do not show universal applicability (Lee et al., 2021).

The study neglects to provide any cost-benefit analysis of implementing AI systems which manufacturers might need to make their decisions.

These methodological boundaries make sure that the assessment approach uses actual data to understand AI's influence on production systems thoroughly.

RESULTS

The findings regarding Artificial Intelligence's influence on manufacturing systems are explored throughout this section by examining both MES and supply chain ordering systems as well as their efficiency in error mitigation and time reduction. Data from 2019 to 2021 between case studies and empirical research together with industry reports formed the foundation for the results.

4.1 Impact of AI on Manufacturing Execution Systems (MES)

MES production efficiency saw significant development after AI integration because of real-time monitoring automation and predictive maintenance features together with production optimization principles. The research from Zhou et al. (2021) demonstrates how AI-driven MES platforms produce enhanced manufacturing precision through operational stoppages reduction leading to better complete equipment efficiency (OEE).

Manufacturing environments can achieve better performance using both traditional MES systems and AI-powered MES systems when viewing Table 1 data for comparison.

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Table 1: Traditional MES vs. AI-Powered MES in Manufacturing

Parameter	Traditional MES	AI-Powered MES
Production Efficiency	75%	92%
Error Rate in Manufacturing	7.8%	2.1%
Downtime Reduction	10%	43%
Predictive Maintenance Accuracy	65%	89%
Energy Consumption Savings	5%	23%

(Source: Wang et al., 2021; Lee et al., 2021)

The investigation demonstrates how AI-enabled MES technology decreases production mistakes improves operational effectiveness and utilizes resources efficiently. When AI powers predictive maintenance it boosts equipment reliability through 43% fewer unexpected failures thereby minimizing maintenance expenses and maximizing production effectiveness (Xu et al., 2021).

4.2 AI Deployments Play a Vital Role in Reducing Manufacturing Errors Made by Humans

Through deep learning algorithms and real-time monitoring plus computer vision AI has transformed defect detection and quality control so that it removes human errors (Chen et al., 2021). Through AI-powered quality control systems organizations can obtain higher product accuracy because the systems detect variables humans cannot see which compromise quality standards.

The table in Table 2 demonstrates how AI solutions drive down manufacturing mistakes in multiple industrial sectors.

Table 2: AI-Driven Error Reduction in Various Industries

Industry	Traditional Error Rate	Error Rate with AI	Reduction Percentage
Automotive	8.2%	2.1%	74%
Electronics	6.5%	1.9%	71%
Pharmaceuticals	5.9%	1.5%	75%
Food Processing	7.1%	2.3%	68%

(Source: Chen et al., 2021; Wang et al., 2021)

4.3 AI in Supply Chain Ordering Systems

AI-powered supply chain ordering systems elevate their forecasting ability for market trends inventory management and supply quality assessment functions. The predictive capabilities of artificial intelligence help manufacturers anticipate industry shifts thus minimizing their deficit between insufficient stock and excessive inventory (Zhou et al., 2021).

Based on their work studying AI-based supply chain decision-making Xu et al. (2021) determined that AI-driven ordering systems achieved a 36% reduction in lead times as well as inventory accuracy reaching a level of 91% (Xu et al., 2021). After AI integration the supply chain operations experience fundamental improvements according to data presented in Table 3.

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Table 3: AI Integration in Supply Chain Operations

Supply Chain Metric	Before AI Implementation	After AI Implementation	Improvement (%)
Lead Time Reduction	7.8 days	5.0 days	36%
Inventory Accuracy	76%	91%	19%
Order Fulfillment Speed	72%	88%	22%
Supplier Performance Rating	79%	94%	19%

(Source: Wang et al., 2021; Lee et al., 2021)

AI assists companies in performing demand forecasting and running automated inventory operations hence companies achieve better supply chain operations with stronger order delivery results.

4.4 AI-Driven Predictive Maintenance and Faster Response Times

The combination of IoT data with sensor data processing enabled by AI algorithms helps detect equipment failure before physical deterioration (Chen et al., 2021). A proactive maintenance strategy lowers unexpected machine outages through its implementation which reduces maintenance costs and accelerates industrial responses.

The predictive maintenance systems developed by Artificial Intelligence allowed businesses to lower their maintenance expenses by a 39% reduction and achieve a 47% reduction in unexpected equipment breakdowns according to Kusiak (2021). Table 4 compares traditional and AI-powered maintenance strategies.

Table 4: AI-Driven Predictive Maintenance vs. Traditional Maintenance

Maintenance Strategy	Unexpected Failures per Year	Maintenance Cost Savings (%)
Traditional Preventive Maintenance	15 failures	0%
AI-Powered Predictive Maintenance	8 failures	39%

(Source: Zhou et al., 2021; Xu et al., 2021)

The results show that AI-based predictive maintenance systems lead to better manufacturing time efficiency thus maintaining uninterrupted production schedules.

This research establishes that AI transforms manufacturing systems through three main advantages which are:

Manufacturing Execution Systems operated by artificial intelligence achieve 72% fewer mistakes and 43% shorter stoppages in production.

Quality control systems powered by AI achieve error reduction of up to 75% within every industrial sector.

Through its application of AI, workers enhance their ability to forecast demand effectively by 91% and decrease order delivery times by 36%.

The application of AI for machine failure predictions enables companies to cut maintenance expenses by 39% and decrease unexpected machinery collapses by 47%

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DISCUSSION

The following part analyzes the information from the Results and Findings to show how AI affects manufacturing systems as well as the adoption constraints and industrial automation expectations in the long run.

5.1 The Transformative Role of AI in Manufacturing Execution Systems (MES)

When manufacturing executes with artificial intelligence systems it achieves better operational effectiveness and enhances operational speed together with error reduction. Manufacturing efficiency has reached 92% through the deployment of AI-based real-time monitoring and predictive analysis and automation technologies (Wang et al., 2021). The increase in manufacturing performance is because AI systems optimize workflows while making decisions automatically and matching production processes to immediate demand with available resources (Chen et al., 2021).

5.1.1 Why AI-Powered MES Outperforms Traditional Systems

AI-powered MES performs constant data analysis through which it detects inefficiencies while optimizing the allocation of resources (Xu et al., 2021).

The automatic removal of human interaction from routine monitoring and quality control saves the system from reporting errors and delays.

The ability of Self-Learning Algorithms lies in their capacity to extract information from production history to achieve process optimization as well as failure prediction and operational workflow adjustment (Lee et al., 2021).

Modern manufacturing corporates need AI to achieve higher operational efficiency with real-time market feedback capability because of its performance advances.

Error reduction in manufacturing receives significant benefits from AI through its implementation described in 5.2.

AI systems that detect defects and perform automated inspections through quality control processes resulted in an important reduction of human mistakes in industrial operations. According to the study AI-powered quality control software lowered defect rates across industries to between 68% to 75% levels (Kusiak, 2021). Computer vision technology machine learning and real-time analytics systems create error-free product evaluations that drive this improvement in quality.

5.2.1 How AI Minimizes Human-Induced Errors

Artificial Intelligence along with Computer Vision & Image Processing systems operates at superior speed and precision to find imperfections that surpass human inspector capabilities (Chen et al., 2021).

Through predictive quality control AI foretells manufacturing errors thereby allowing producers to modify operational parameters during active production.

AI systems operate according to set evaluation rules so they remove human oversight and personal biases from inspections (Wang et al., 2021).

The technological advancements enhance both product quality and reduce rework costs and lead to better customer satisfaction which establishes the vital position of AI in smart manufacturing.

The implementation of AI enhances supply chain efficiency together with order management through its various capabilities.

Manufacturers use AI to transform their supply chain ordering systems which now efficiently manage inventory as well as forecast demands and process orders. The research confirmed that AI-managed supply chains cut down lead times by 36% while achieving 91% enhanced inventory precision according to Zhou et al. (2021).

5.3.1 Key AI-Driven Improvements in Supply Chains

Through the analysis of historical data coupled with market trends, AI makes demand forecasts that protect companies from stock surpluses or insufficiency (Xu et al., 2021).

The supply chain system utilizes AI to assess order processing dynamically through data received from supplier operations and transportation functions along with recognition of market signals (Lee et al., 2021).

The system demonstrates ongoing supplier assessment features through delivery performance checks alongside quality inspection and cost-quality evaluation methods to provide manufacturers with optimal resources at reduced expenses.

The application of AI proves essential in modern manufacturing because it provides supply systems with adaptive capabilities and financial savings along with faster customer service.

5.4 AI-Driven Predictive Maintenance and Its Benefits

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Man-made intelligence-based predictive equipment maintenance results in reduced hardware breakdowns which leads to higher operational effectiveness with lower amounts of unexpected system stoppages. Research showed that AI-based maintenance systems resulted in a 47% decrease in unanticipated equipment breakdowns as well as maintenance expenses which declined by 39% (Kusiak, 2021).

5.4.1 How AI Enhances Predictive Maintenance

AI-equipped IoT sensors from the Internet of Things system keep close track of machinery performance through real-time monitoring to detect potential equipment failure symptoms (Zhou et al., 2021).

AI uses equipment historical data inputs to make future maintenance requirements predictions thus avoiding operational breakdowns (Chen et al., 2021).

AI-based work order automation enables necessary equipment maintenance scheduling which cuts down unnecessary downtime as well as operational expenses (Lee et al., 2021).

5.5 Challenges in AI Adoption in Manufacturing

Manufacturing facilities encounter multiple hurdles while trying to implement artificial intelligence for transformational benefits.

5.5.1 High Implementation Costs

AI-driven MES together with supply chain management systems and predictive maintenance platforms require major capital investments to buy hardware and software while employees need training (Xu et al., 2021). Small businesses together with medium-sized enterprises find it difficult to dedicate their funds to fully integrating artificial intelligence into operations.

5.5.2 Workforce Resistance and Skill Gaps

AI implementation remains challenging because most factory employees do not possess sufficient technical skills in AI systems. Fear of job replacement prevents many organizations from adopting AI implementations according to Wang et al. (2021).

5.5.3 Data Privacy and Cybersecurity Risks

AI-driven manufacturing systems that process numerous real-time datasets during production operations are at high risk of cyber-attacks along with data network breaches (Chen et al., 2021). Security measures need to be implemented with great strength to reduce these risks.

5.5.4 Integration with Legacy Systems

Because most manufacturers operate with outdated IT systems and operational frameworks AI integration remains difficult for them. The implementation requires a fundamental compatibility check between AI technologies and a manufacturer's current infrastructure according to Lee et al (2021).

5.6 Long-Term Implications of AI in Manufacturing

Manufacturing will experience advanced modifications because of AI technologies which will generate lasting effects on production systems.

Industry 4.0 adoption increases due to AI serving as its primary catalyst to create self-operational smart manufacturing environments (Xu et al., 2021).

The collaboration between humans and AI involves joint work where machines enhance human performance instead of replacing them thus resulting in positions managing AI systems and analyzing data in addition to optimizing processes through AI methods (Chen et al., 2021).

The implementation of AI for manufacturing applications leads to reduced manufacturing waste and environmental footprint as well as decreased energy usage (Wang et al., 2021).

Manufacturers adopting AI for their operations will achieve higher efficiency and quality production while enhancing market response speed leading to better competitiveness globally (Zhou et al., 2021).

CONCLUSION AND RECOMMENDATIONS

Conclusion

Manufacturers have seen a revolutionary shift through Artificial Intelligence integration during which Manufacturing Execution Systems (MES) and supply chain ordering systems while predictive maintenance have drastically improved.

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AI technology demonstrates its ability to lower human mistakes and boost production speed as well as decrease manufacturing timetable durations.
The implementation of AIulfilled MES systems leads to workflow automation which raises productivity rates between 75% and 92%.
AI-quality control systems boost production quality so defects decrease by 75% thus reducing unnecessary waste while increasing product uniformity.
AI technologies employed for supply chain management systems shorten lead times by 36% while improving inventory accuracy by 91% which enables better forecasting and quicker order delivery.
The implementation of AI-based predictive maintenance practices results in a 47% decrease in unexpected equipment failures while simultaneously reducing maintenance expenses by 39% which promotes continuous industrial operations.
The study conveys awareness about different obstacles preventing AI adoption while showing appreciation for its numerous positive aspects.
AI will sustainably advance Industry 4.0 adoption while developing sustainable human-AI partnerships for manufacturing alongside global industrial competitiveness assessment. For manufacturers to achieve maximum benefits from AI they need to plan their approach to implementation along with handling the existing barriers.
Recommendations
The investigation's findings guide essential suggestions for AI adoption to both manufacturers and policymakers together with industrial players which will maximize system benefits.
6.2.1 Investing in AI Infrastructure and Digital Transformation
Manufacturers need to establish AI-based system implementations for MES and supply chain operations to achieve maximum operational efficiency.
Manufacturers who implement cloud-based AI resources along with IoT technology in production processes will achieve efficient integration of artificial intelligence and data-driven operational decision systems.
6.2.2 Workforce Upskilling and AI Training Programs
Managers need to provide instruction to workers about how AI systems work and both machine learning technologies and data analytics approaches to close skill deficiencies.
Businesses need to team up with universities along with technical institutes to establish training programs focused on AI topics.
6.2.3 Strengthening Cybersecurity Measures in AI Systems
AI-specific cybersecurity guidelines need to be implemented to defend manufacturing information from cyber-based attacks and unauthorized access (Zhou et al., 2021).
Industrial anomaly detection systems using artificial intelligence should be installed for continuous monitoring of cybersecurity flaws and to stop attacks.
6.2.4 Enhancing AI Integration with Legacy Manufacturing Systems
Hybrid AI models enable manufacturing operations because they enable a smooth fusion of new technology with existing MES and ERP systems according to Lee et al. (2021).
Public financial programs and government support mechanisms enable SMEs to start their journey toward AI-based manufacturing operations.
6.2.5 Promoting Ethical AI Adoption and Regulatory Compliance
Manufacturers need to guarantee that AI-run decisions maintain ethical principles for labor practices as well as environmental sustainability and fair employment standards.
Standards of regulatory compliance should be created to achieve transparency in AI systems along with data privacy protections and responsible AI system implementation (Wang et al., 2021).

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