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THE DESIGN OF INTELLIGENT COLLABORATION PLATFORM FOR AUTOMOBILE MANUFACTURING UNDER THE BACKGROUND OF INDUSTRY 5.0

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Abstract: Based on Industry 5.0, this paper proposes an intelligent collaboration framework in the field of automobile manufacturing, emphasizing the three core concepts of people-centered, sustainability and resilience. The framework integrates artificial intelligence, network and collaborative technology to realize the transition from Industry 4.0 to 5.0, strengthen human-machine collaboration through artificial intelligence technology, and improve overall efficiency. The people-oriented design focuses on reducing the burden on employees, meeting individual needs and ensuring health and safety, highlighting humanistic care. Sustainability design focuses on environmentally friendly materials and supplier selection, energy optimization and environmental testing to reduce pollution, waste and achieve green production. Resilient design improves the adaptability and resilience of production systems in the face of challenges, and improves production flexibility and continuity through modular, intelligent scheduling and risk prediction mechanisms.
Keywords: Industry 5.0; Artificial intelligence; Automobile manufacturing; Platform design

1 INTRODUCTION

In the process of global industrial development, the EU officially announced the " Industry 5.0 : Towards a Sustainable, Human-centric and Resilient European Industry " report in April 2021, which established the basic concept of " Industry 5.0. "[1] In addition to the EU 's proposal that Industry 5.0 has three characteristics of human-centricity, sustainability and resilience, Zhuang et al.added the ' intelligence ' feature[2].

Domestic and foreign scholars have studied the application ways and supporting technologies of Industry 5.0. Slavic et al. conducted a survey on the European manufacturing industry and found that "people-centered" in Industry 5.0 includes the ability training of production employees as a focus on completing specific tasks, improving material consumption efficiency to promote sustainable development, and using standardized and detailed work instructions to make the system resilient [3]. Maddikunta discussed the potential applications of Industry 5.0 based on edge computing, digital twins, collaborative robots, Internet of Things, blockchain, 6G and other technologies in smart healthcare, cloud manufacturing, supply chain management and manufacturing production [4]. After analyzing the advantages, disadvantages, opportunities and threats brought by Industry 5.0 with SWOT, Kovari found that it is possible to achieve sustainable development goals and gain competitive advantages with industry 5.0, but attention should be paid to integrating human resources into the production process and dealing with safety and ethics issues [5]. Zhang Lili applied Industry 5.0 to enterprise human resource accounting and integrated accounting models, measurement methods and account Settings [6]. Jiang Zhoumingchi proposed a human-machine collaborative augmented manufacturing reference framework for industry 5.0, established a three-level product-economy-ecology model, and systematically expounded its core concepts, key technologies and typical scenarios through the development of human-information-physical system theory [7]. To sum up, foreign scholars have carried out extensive and in-depth application research, not only discussing the potential impact of industry 5.0 in multiple industries, but also conducting detailed discussion and verification for specific technical applications. In contrast, domestic scholars focus more on the concept definition and theoretical discussion of industry 5.0, although there is no lack of awareness of its importance, but relatively little research in the field of practical application.

In recent years, with the continuous innovation of production technology, some progress has been made in production efficiency and cost control. However, although the level of automation in the automobile manufacturing industry has been improved, there are still certain deficiencies in the fine management and intelligent application [8-9], which not only limits the further development of the automobile manufacturing industry, but also affects its competitiveness in the global industrial chain.With the continuous advancement of the industrial revolution, the automobile industry, as an important part of modern industry, is facing challenges and opportunities. The advent of Industry 5.0 provides new ideas for the intelligent, networked and collaborative automobile manufacturing industry. At present, the automobile manufacturing field is experiencing a profound change from traditional manufacturing to intelligent manufacturing, and the traditional automobile manufacturing mode has been difficult to meet the market demand in terms of efficiency, cost, quality and so on. How to improve the intelligent level of automobile manufacturing and realize the efficient collaboration of all links has become an urgent problem for automobile manufacturing enterprises.

This paper combines the three core features of industry 5.0: human-centered, sustainability and toughness to build an intelligent collaboration platform for automobile manufacturing to comprehensively optimize the automobile manufacturing process. The intelligent collaboration platform built can improve the production efficiency and product

quality of the automobile manufacturing process, and also meet the diversified value needs of employees, society and the environment and other stakeholders, reflecting the importance of social responsibility.

2 DESIGN OF INTELLIGENT COLLABORATION PLATFORM FOR AUTOMOBILE MANUFACTURING

Based on the three core concepts of Industry 5.0 generally recognized by the international community: people-oriented, sustainability and resilience as theoretical support, the intelligent collaboration platform for automotive manufacturing is built, as shown in Figure 1.

In practical applications, the human-centered concept includes the integrated application of intelligent job assistance systems to improve production efficiency and enhance job safety. In order to meet the individual operation needs of employees, the design of personalized work interface makes the working environment more convenient and easy to understand. Implementation of a health and safety monitoring system to improve workplace safety and the physical and mental health of employees.

In terms of environmental sustainability, the platform implements the concept of green supply chain management to realize the greening of the entire supply chain and the efficient use of resources. Energy management and optimization measures minimize energy consumption in the production process. Environmental monitoring and reporting mechanism can be set up to monitor and evaluate the impact of production activities on the environment in real time, and realize the environmental protection of the production process.

The concept of system resilience is reflected in the adaptability of future technology and market changes. The modular and scalable design allows the system to easily respond to technology upgrades and market changes. The construction of intelligent scheduling and cooperative system can realize efficient coordination and adaptive adjustment of production process, and improve the continuity and stability of production. Risk prediction and response mechanism can identify and respond to potential production risks in advance to ensure smooth production.

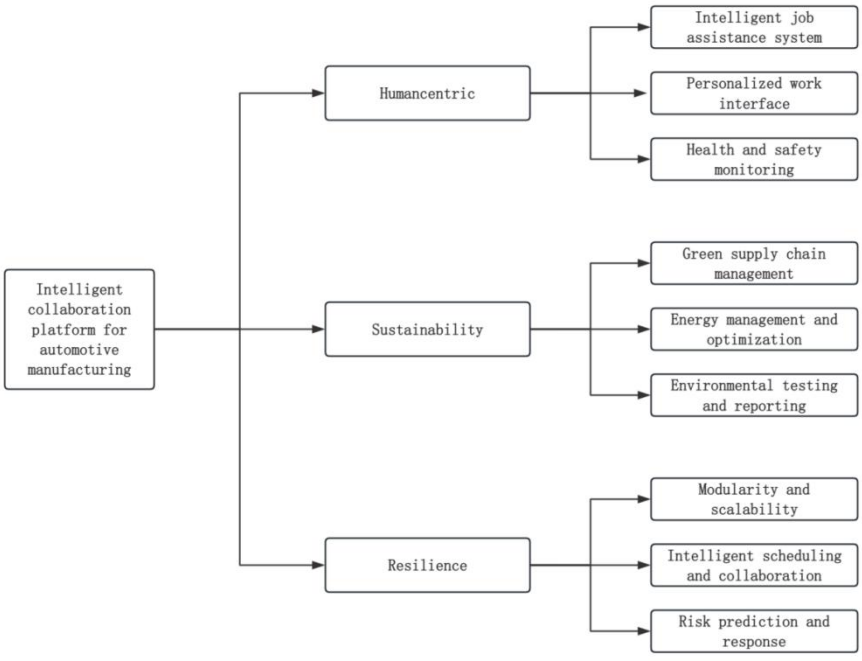

Figure 1 Intelligent Collaboration Platform for Automobile Manufacturing

3 PEOPLE-ORIENTED PLATFORM DESIGN

3.1 Intelligent Job Assistance System

The Intelligent Job Assistance System is a comprehensive solution that integrates advanced technologies to increase productivity, reduce error rates, reduce employee burden, and ensure employee safety in the automotive manufacturing process. As shown in Figure 2, the system is composed of intelligent devices, sensor networks, central control systems and human-computer interaction interfaces to achieve intelligent management and optimization of production processes. In the field of automobile manufacturing, the advanced technology of intelligent job assistance system integration has brought significant improvement to the entire manufacturing process [10].

(1) High-performance intelligent equipment. Automated robots and production lines can independently complete complex production tasks such as stamping, welding, and painting with little or no human intervention. Through the built-in algorithm, the equipment can realize self-optimization and adjustment to adapt to the production needs of different models and parts, ensuring the efficiency and flexibility of automobile manufacturing to meet the rapidly

changing needs of the market.

(2) Sensor network. In the stamping, welding, painting and other production lines of automobile manufacturing, various sensors are arranged to monitor temperature, pressure, speed and other parameters in real time, and the sensor transmits the data to the central control system in real time to provide accurate data support for production. Based on data analysis, the system can accurately judge the production status, predict potential problems, and automatically adjust equipment parameters or take corresponding measures to ensure the stability and safety of the production process.

(3) Central control system. The system is responsible for receiving sensor data, processing instructions, coordinating equipment operation and other tasks. Based on data processing ability and intelligent decision-making ability, the system can automatically adjust production parameters and equipment operation status according to real-time data and analysis results, and optimize the production process. The central control system can also be integrated with ERP, SCM and other management systems to realize the sharing and collaborative management of production data, and provide more comprehensive and accurate data support for enterprise decision-making.

(4) Human-computer interaction interface. The human factor engineering-based interface takes into account employee habits and visual needs to facilitate automotive manufacturing employees. Facilities such as safety guardrail and emergency stop button are set up around the production line, so that employees can take quick measures in emergency situations to avoid accidents. The intelligent operation assistance system also has the function of employee location and movement monitoring, once the dangerous actions of employees are found, the system will immediately send an early warning signal and start emergency measures to ensure the safety of employees.

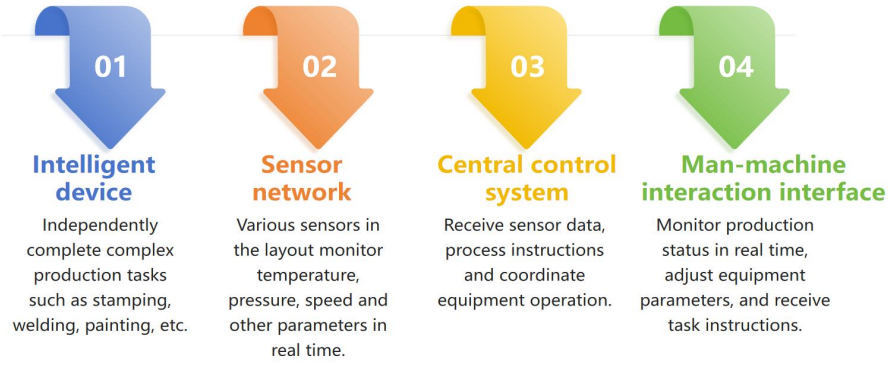

Figure 2 Intelligent Job Assistance System

3.2 Personalized Work Interface

Intelligent job assistance system integrates advanced industrial Internet technology to meet the diversified operating habits and preferences of workers by introducing personalized work interface, which allows workers to customize according to their own operating habits and preferences [11]. Different workers may have different needs for information display and operation, and personalized customization can improve operating efficiency and reduce the error rate.

In the automotive manufacturing process, workers need to frequently operate various equipment and systems, personalized work interface can not only reduce the adaptation time of workers in the operation process, but also reduce production accidents and product quality problems caused by misoperation. The personalized work interface of the intelligent job assistance system allows each worker to customize it according to their own work characteristics and needs. Different workers may have different requirements for the display mode of information, the order of arrangement and the layout of the operation interface, and the personalized work interface is more in line with personal operation habits.

The personalized work interface provides a real-time feedback mechanism that makes it easy for employees to advise on issues in the production process. Workers can view the production data, equipment status, product quality and other information on the platform interface in real time, and can deal with and feedback on abnormal situations in time.

3.3 Health and safety monitoring system

The integration of health and safety monitoring systems improves the level of safety management in the automotive manufacturing industry and enhances the safety of workers. The health and safety monitoring system provides detailed health data and safety records, provides strong support for the health management and safety assessment of enterprises, and helps to enhance the job satisfaction and loyalty of workers, stimulate the work enthusiasm and creativity.

In the automotive manufacturing industry, health and safety monitoring systems reflect the care of workers' health. As shown in Figure 3, in recent years, the automobile manufacturing platform is gradually integrating health and safety management system, which ensures the safety of the production process by monitoring the physical condition of workers and the safety status of the working environment in real time, and sending abnormal information to the mobile device of the manager, and starting the alarm system when necessary.

The platform monitors workers' heart rate, blood pressure and other key physiological indicators in real time through

wearable devices such as smart wristbands. With high-precision biosensing technology, the equipment can collect data continuously and transmit it to the management system in real time through wireless network [12]. Video surveillance and sensor technology monitor the safety status of the production site in real time. Hd cameras are installed at key locations in the production line to monitor the situation on the production site in an all-round way. A variety of sensors are deployed in places such as machinery, work areas and passageways to detect safety related parameters such as temperature, humidity, smoke and hazardous gases.

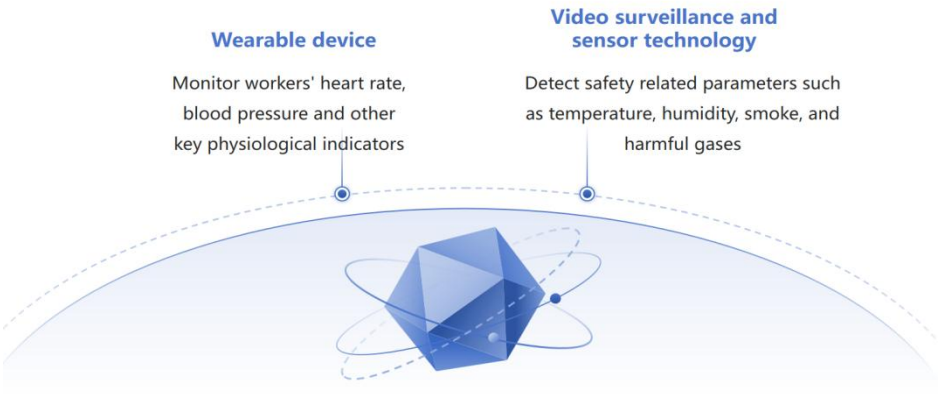

Figure 3 Health and Safety Monitoring System

4 SUSTAINABLE PLATFORM DESIGN

The application of the sustainable design concept of Industry 5.0 in automotive manufacturing is reflected in the design stage of the product, throughout the production and use process, as shown in Figure 4.

In terms of material selection, automobile manufacturers are increasing the use of recyclable, renewable or environmentally friendly materials to reduce the production of environmental pollutants while improving the environmental performance of vehicles. For example, the use of lightweight alloy materials can reduce the weight of cars, thereby reducing fuel consumption and emissions; The use of bio-based materials instead of traditional petroleum-based materials can reduce the dependence on fossil fuels.

Energy saving and emission reduction are the goals of sustainable design. Automotive manufacturers optimize production processes and equipment to reduce energy consumption and waste emissions. Adopt advanced stamping, welding, painting and assembly technology to improve production efficiency and material utilization; Active use of solar, wind and other clean and renewable energy sources to power the production process.

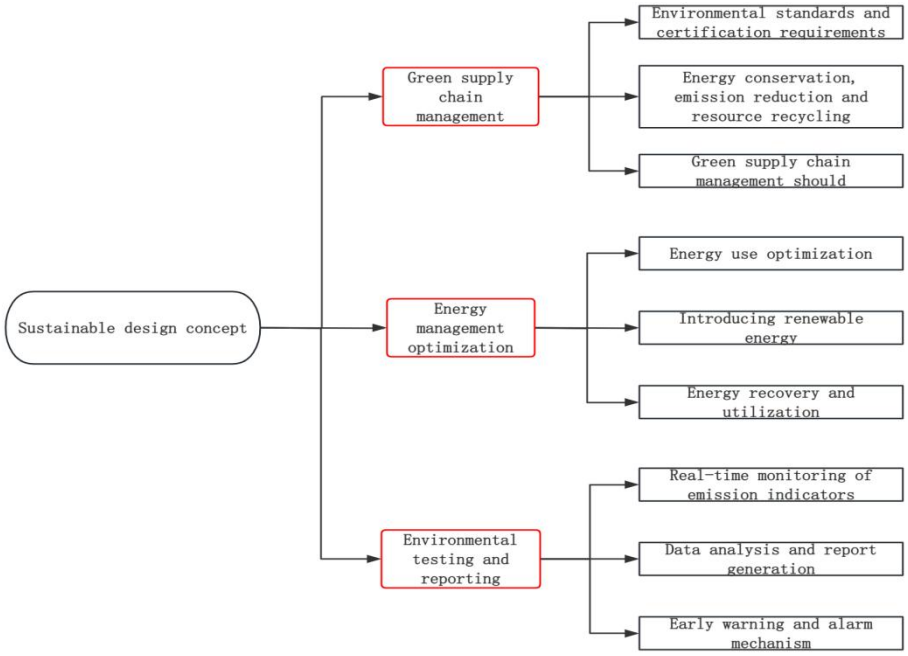

Figure 4 Sustainable Design Concept

4.1 Green Supply Chain Management

Green supply chain management requires enterprises to pay attention to environmental protection and resource conservation in the supply chain to achieve a win-win situation of economic and environmental benefits [13]. In partnership with certification bodies, automotive manufacturers can audit and certify key links in the supply chain to make suppliers and manufacturers comply with environmental regulations and standards. Enterprises adopt efficient production processes and equipment to reduce waste emissions; Encourage suppliers to adopt environmentally friendly packaging and transportation methods to reduce their environmental impact; Promote the recycling of waste, reduce the need for raw materials, and achieve the recycling of resources.

Green supply chain management should establish a cooperative relationship with suppliers, automotive manufacturing enterprises and suppliers to jointly develop environmental management plans, comply with environmental regulations and standards, share environmental technology and experience, and jointly promote the environmental protection and sustainability of the supply chain. Green supply chain management requires the support of information sharing and transparency. Based on data sharing and Internet technology, automobile manufacturers can monitor and manage the sustainability of raw material procurement, parts production, logistics distribution, product manufacturing until the final sales and recycling of the supply chain in real time.

4.2 Energy Management and Optimization

The function of the platform is to integrate all kinds of energy data acquisition equipment, and obtain the energy consumption data of each link in the production line in real time and accurately. The platform monitors energy consumption in the automotive manufacturing process and provides a visual display function to present complex energy data in an intuitive, easy-to-understand chart form. The platform can further process the data, dig and analyze the collected energy data in depth, and identify the main bottlenecks of energy consumption and potential optimization space [14].

(1) Optimization of energy use

Based on the platform's analysis of energy consumption bottlenecks and optimization space, specific energy-saving measures are formulated. First, improve the process, improve production efficiency and reduce ineffective energy consumption and other ways to reduce energy consumption. Second, the use of advanced energy-saving equipment and technology to improve the energy efficiency of equipment. Third, strengthen energy management, promote the realization of more comprehensive energy-saving goals by improving the awareness of employees, and further promote sustainable development.

(2) The introduction of renewable energy

In order to further reduce carbon emissions and energy consumption, the introduction of renewable energy in the production process, such as the installation of solar power generation systems on the factory roof, using solar energy to provide part of the power supply for the production line; The construction of wind power stations in areas rich in wind resources provides clean energy for automobile manufacturing, thereby reducing production costs.

(3) Energy recovery and utilization

In the process of automobile manufacturing, energy recovery and utilization technology is introduced to realize the efficient use of energy. For example, the use of waste heat to generate electricity, recycling useful components in waste gas, etc., can reduce energy consumption, reduce environmental pollution and waste emissions.

4.3 Environmental Testing and Report

In the process of the automobile manufacturing industry's transformation to industry 5.0, the environmental monitoring and reporting system reflects the enterprise's commitment to environmental protection and the advanced level of industrial intelligent and digital management [15].

The environmental monitoring and reporting system takes ESG as the core driving force, and comprehensively covers the environmental monitoring of the whole process of automobile manufacturing by building an integrated and intelligent platform. Using Internet of Things (IoT) technology, the system deploys a network of sensors at key locations in the production line to collect data on emissions such as gas, wastewater, and solid waste in real time and transmit the data to a central processing unit.

In terms of environment (E), the system is densely packed with a network of sensors in the production line to monitor data on emissions such as gas, wastewater and solid waste in real time. The environmental monitoring and reporting system has the function of data analysis and report generation. Based on machine learning analysis and other technologies, the collected data is deeply processed and analyzed to extract valuable environmental protection information.

On the social (S) side, the Environmental Monitoring and reporting system focuses on the environmental performance of enterprises and emphasizes the social responsibility of enterprises. The system tracks the environmental protection input and results of enterprises in real time, and supervises the implementation of their commitments to society. The system provides decision support for enterprises, helps enterprises to better manage environmental affairs, and improves the reputation and influence of enterprises in society.

In terms of governance (G), based on transparent and standardized environmental management, the system records and reports the environmental protection data of enterprises in real time, providing accurate and comprehensive information for regulators. The system has an early warning mechanism, when the emission data exceeds the preset threshold, the

system will trigger an alarm to remind the enterprise to take effective measures in time.

5 THE PLATFORM DESIGN OF TOUGHNESS

The concept of resilient design emphasizes the ability of a system to maintain its function and performance in the face of uncertainty. As Figure 5 shows, in automotive manufacturing, a highly flexible and adaptable production system can effectively cope with the challenges of fluctuating raw material supply, changes in market demand, and technological updates.

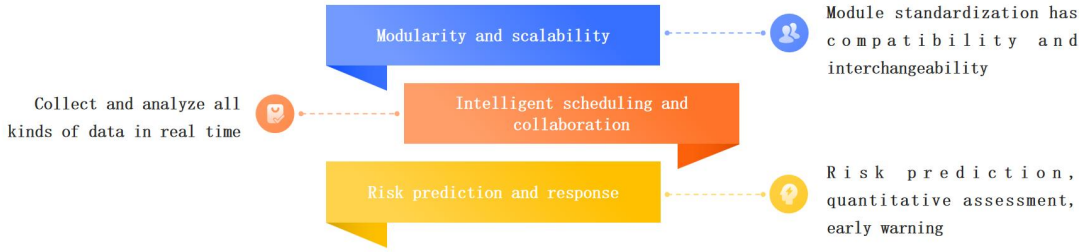

Figure 5 Toughness System

5.1 Modularity and Scalability

Modular design makes the manufacturing process of the car more flexible and efficient by dividing the car into multiple independent assemblies or modules, each with specific functions and interfaces.
According to the function and performance requirements of the car, the whole vehicle is divided into engine module, chassis module, body module, electronic and electrical module. Each module contains a set of related parts and subsystems to achieve a specific function; Module standardization Develop unified module interface standards and specifications to achieve compatibility and interchangeability between different modules; Each module is relatively independent and can be designed, manufactured, tested and verified independently, helping to reduce design risk, improve product quality, and facilitate subsequent module replacement and upgrade.
Extensibility design is an extension of modular design, emphasizing that on the basis of meeting current requirements, the system has the ability to adapt to changes in future requirements. Function expansion in automotive manufacturing By adding new modules or improving the function of existing modules, to achieve the expansion and upgrading of automotive functions. For example, the intelligent driving module is added to realize the automatic driving function of the vehicle; Add the entertainment information system module to improve the intelligence of the vehicle.

5.2 Intelligent Scheduling and Collaboration

In the field of automobile manufacturing, the design concept of toughness is combined to build an intelligent scheduling and collaborative system to effectively improve production efficiency, respond to market changes and enhance enterprise adaptability [16].
Intelligent scheduling system shows great potential and value in modern production environment through deep integration of artificial intelligence technology [17]. Based on big data and AI algorithms, the system collects and analyzes equipment operating status, material inventory changes, order demand information and other types of data in the production process in real time and accurately. Based on data analysis, the system automatically adjusts production plans and optimizes production processes. Using machine learning algorithms, intelligent scheduling systems can predict equipment failures and maintenance needs, schedule maintenance plans in advance, reduce equipment downtime, and improve production efficiency. Based on real-time data and preset rules, intelligent scheduling system can make production task allocation, production sequence optimization and other decisions, reduce human errors and improve the accuracy of production decisions.
In the process of automobile manufacturing, different departments and different production links need to realize real-time information sharing. By building a unified information platform, the collaborative system can realize real-time update and sharing of production data, equipment status, material inventory and other information. The collaboration system supports cross-departmental and cross-domain collaboration. Information sharing and real-time communication between different departments make it possible to work together more efficiently to solve problems in the production process. The collaborative system involves the collaboration with suppliers, logistics service providers and other external partners to achieve supply chain optimization and collaboration, and improve the efficiency of the entire automobile manufacturing process.
The resilient design concept emphasizes the ability of the system to recover quickly after damage. In the intelligent scheduling and cooperative system, the system can quickly resume operation in the case of equipment failure and network interruption, and continue to provide support for production.

5.3 Risk Prediction and Response

The risk prediction system collects data from different aspects of the production process, and on the basis of data analysis, the risk prediction system identifies various risks such as supply chain, technology and market. The system makes a quantitative assessment of various risks to determine their likelihood and impact. When potential risks are identified, the risk prediction system sets an early warning threshold and issues an early warning when the risk indicator exceeds the threshold. The system uses advanced algorithms such as machine learning to predict risks and provide basis for enterprises to formulate coping strategies in advance [18].

Based on the results of risk prediction, the enterprise makes corresponding emergency plans and clarifies key information such as response measures, responsible persons and implementation time. For different types of risks, enterprises need to allocate resources reasonably to respond to risks quickly. At the same time, enterprises also need to optimize the production process, improve the utilization rate of equipment and other ways to reduce the possibility of risk. Risk response requires the close coordination of various departments within the enterprise, and the enterprise needs to establish a cross-departmental communication mechanism, so that all departments can quickly cooperate in the risk response process. When the risk occurs, the enterprise needs to quickly adjust the production plan, optimize the allocation of resources and other strategies, and restore the production order after the risk is removed.

6 CONCLUSIONS AND PROSPECT

Based on the human-centric, sustainability and resilience concepts of Industry 5.0, this paper proposes the concept of an intelligent collaboration platform for the automotive manufacturing industry. The platform integrates intelligent, networked and collaborative technologies to give play to the advantages of humans and machines, improve manufacturing efficiency and product quality, reflect the diversified value needs of employees, society and the environment and other stakeholders, and highlight the awareness of social responsibility in the automotive industry.

First, the people-oriented design concept is based on intelligent work assistance system to reduce the labor intensity of employees, personalized work interface to meet the personalized work habits of employees, and health and safety monitoring system to ensure the safety and health of employees, show comprehensive care and respect for employees, and further create a healthy working environment for manufacturing enterprises.

Secondly, the concept of sustainable design focuses on environmental protection and efficient use of resources. Green supply chain management reduces pollution and waste in the production process. Energy management and optimization reduce energy consumption and carbon emissions in the production process by improving energy efficiency and adopting renewable energy sources.

Third, the design concept of resilience improves the adaptability and resilience of the production system through the three core functions of modularity and scalability, intelligent scheduling and coordination, and risk prediction and response, and helps enterprises to warn in advance and respond quickly to risks such as supply chain disruptions and natural disasters, and maintain the continuity of production.

For the future, Industry 5.0's concept of intelligent collaboration in the field of automotive manufacturing will continue to deepen and expand. With the continuous emergence of new technologies, such as the integration of quantum computing and biotechnology, the intelligent level of automobile manufacturing will be further enhanced. The deepening application of artificial intelligence will play a more important role in product design, production automation, quality control and other aspects, and promote the development of automobile manufacturing to a more efficient and accurate direction. Digitalization and data-driven decision making will become the new normal, helping automakers achieve more accurate market forecasting and production optimization.

COMPETING INTERESTS

The authors have no relevant financial or non-financial interests to disclose.

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