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Intelligent Transformation of Process Flow System in 5G Era

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Abstract

Based on the background of 5G era, this paper studies and analyzes the influence that the development of communication technology will bring to the industrial manufacturing industry. It is considered that the development of intelligent manufacturing must be unmanned in the 5G era. The specific application scenarios of 5G in intelligent process flow are analyzed.

Keywords

5G; Intelligent manufacturing; Unmanned manufacturing.

1. Introduction

If the appearance of 4G breaks the boundary between time and space and completes the connection between people, then the appearance of 5G will complete the connection between people and things. 4G has changed people's life and entertainment style, while 5G will change enterprises, industries and even the whole society. The most intuitive feeling of 5G for ordinary consumers is probably higher network speed. The extremely fast transmission speed and huge network capacity of 5G can bring extremely smooth page loading and extremely rapid video downloading, which can greatly enhance users' online experience. In the future, the industrial application of 5G, the large-scale development of wearable devices, smart homes, self-driving cars and telemedicine will further enrich people's daily work, learn how to live and play.

After experiencing the financial crisis, the U.S. government realized the drawbacks of virtual economy and the importance of traditional manufacturing, shifted its focus to manufacturing, and introduced the "American Industrial Internet" strategy to defend its dominance. In order to realize the transformation and upgrading of manufacturing and catch-up, Germany, China and other major manufacturing countries have successively introduced development plans such as "German Industry 4.0" and "Made in China 2025" .

Manufacturing is the foundation of economic stability and prosperity, and a country's industrial level influences its comprehensive strength to a great extent. If the first three industrial revolutions have brought human society into mechanization, electrical automation and informationization respectively, then the upcoming fourth industrial revolution will bring human society into intelligence.

The third industrial revolution enabled machines and equipment to generate and store a large amount of data, so that human beings can analyze and use these data to make more accurate decisions. However, the data connection has not been further optimized. Under the traditional mode, manufacturing enterprises use wired technology to connect all kinds of equipment, which is very limited in terms of speed, distance, capacity and cost. A few years ago, the industrial application of wireless technologies such as WIFI and Bluetooth broke the transmission distance and reduced the cost of equipment connection, but problems in bandwidth, reliability and security still existed. In recent years, the development of 5G has led human society into the fourth industrial revolution. Compared with 4G network technology, 5G has been improved in all aspects, with faster transmission speed, larger network capacity, lower delay and higher reliability. The intelligent development trend of manufacturing industry

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makes the industrial application of 5G become the core of the fourth industrial revolution and the new kinetic energy for traditional enterprises to transform into intelligent enterprises.

2. Literature review

Undoubtedly, the arrival of 5G will subvert the whole society, and many scholars have expressed their views on the development of 5G. Wang Hucheng et al. (2015) analyzed the future development trend of 5G technology, which can be summarized as follows: SDN and NFV become platform supporting technologies, the network is dynamically sliced, and the network capability is deeply open. Felita and Suryanegara(2013) determined that the challenges of 5G technology are mainly related to security and dealing with limited spectrum resources, and concluded that the innovation opportunities of 5G lie in the research on security, network, technology implementation and application. Zhang et al(2019) believes that besides enhanced mobile broadband communication services, the emergence of 5G aims to support various innovations in vertical industries. Faye Wong (2019) thinks that 5G will realize the connection between people and things, so it has great potential in changing industry. Gong Shulei and others (2019) think that the core value of 5G in the future is reflected in industrial enterprises, and summarize three application modes: "shift" for "solid", "soft" for "hard", and "set" to "divide". The business scenarios of 5G applied to manufacturing enterprises are divided into three categories: location-related, monitoring-related and automation-related. Xie Jianchao (2019) thinks that 5G services will be applied to the industrial field first, and manufacturing enterprises will become the first 5G customers of operators. Meanwhile, Wang Xiaopeng and Deng Pingping (2020) listed four major security challenges that 5G faces: network security, business application security, data security and information content security. Li et al(2011) proposed a secret version of adaptive frequency hopping, which combines 5G technology with other technologies to estimate the quality of service through physical layer parameters. Khajuria and Skouby discussed user privacy and economic issues in the 5G era, which enabled the new business model to reflect economic value.

5G promotes the development of industry by realizing intelligent manufacturing and internet of things. Peng Hu et al. (2019) believe that the Internet of Things based on 5G has the characteristics of rapidity, convenience and economy, and the organic integration of 5G technology and the Internet of Things makes the Internet of Things go deep into all walks of life. Lele Wu (2019) thinks that the relationship between 5G and the Internet of Things lies in its advantages and characteristics of low delay, high reliability and high flexibility, which lays a good foundation for the practical application of the Internet of Things. At the same time, the demand of Internet of Things for 5G technology promotes the all-round development of 5G. Conran(2019) said that the data growth brought by 5G gives artificial intelligence the greatest opportunity, and at the same time, artificial intelligence can help build 5G infrastructure. Pengfei Song (2019) believes that the extremely low delay of 5G technology ensures the requirements of real-time monitoring and control in the industrial field; High reliable network quality ensures the stability requirements of industrial systems; Large bandwidth can realize high-definition 3D video, AR transmission and even remote control.

For the development of intelligent transformation of industrial enterprises, Huang Wei and Shen Mingyan (2019) believe that the research direction of intelligent industrial Internet of Things includes: 1. Security issues; 2. Heterogeneous network convergence; 3. Mass information cleaning, processing, analysis and application. According to Qin and Cheng(2017), the future digital design and manufacturing research includes four main research perspectives related to manufacturing process, equipment, software and engineering. The key technologies to realize the manufacturing environment of Industry 4.0 are three interdependent information and communication technologies: Internet of Things, network physical system and intelligent

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factory. Wang Kefan (2018) divided the application of artificial intelligence in Industry 4.0 into four categories: on-site intelligent control technology, on-site intelligent monitoring technology, intelligent manufacturing system and equipment state prediction and maintenance. Walia et al(2019) thought that 5G would improve the flexibility and service quality of factories through network slicing, and proposed a network slicing management model based on 5G. Fox and Subic(2019) reported a 3D printing method using multi-head automatic fiber/tape laying technology, which can produce large-scale products in the same way as traditional production methods, and is beneficial to realize the intelligentization and digitalization of the production process. Tien(2017) believes that real-time decision-making is an indispensable part of the Internet of Things and artificial intelligence. Lee et al(2017) proposed an industrial Internet of Things suite consisting of an industrial Internet of Things cloud platform based on microservices and an intelligent hub based on industrial Internet of Things, which is conducive to re-industrialization in the 5G era.

3. The Internet of Things architecture in the production process

Integrating the Internet of Things technology into industrial manufacturing means integrating sensors with sensing and identification functions into the production process, so that production equipment can be supervised at any time and perform corresponding production tasks according to real-time instructions. The smooth progress of the whole process requires the cooperation of three layers, namely, sensing layer, network layer and application layer.

Sensing layer is the end closest to production equipment, which is mainly composed of a large number of sensors with functions of calculation, storage, selection and connection. The sensing layer collects and records the relevant information of workshop environment and equipment status with the help of various sensors distributed in the production system, such as acoustic sensors, pressure sensors and humidity sensors, and processes these data according to its own logical ability, and selectively transmits effective data.

The function of the network layer is to realize the data transmission between the sensing layer and the application layer. It transmits the data information obtained by the sensing layer to the application layer platform and displays the data in a visual form. Industrial Internet of Things has higher requirements on the network layer, and massive data needs to be transmitted safely, timely, stably and reliably through the network layer. The traditional 2G, 3G and 4G can not meet such difficult transmission requirements. In this case, 5G provides a guarantee for the industrial Internet of Things network layer with its ultra-fast transmission speed, large network capacity, ultra-high reliability and ultra-low delay.

The application layer is composed of a unified cloud platform, and managers can know the running status of equipment in real time through the data collected by the perception layer, and analyze and process it so as to make a response decision. These decisions will be converted into instructions that can be understood and executed by machines and devices, thus realizing accurate information interaction and efficient cooperation between people and devices.

On the basis of sensing layer, network layer and application layer, workers, robots, transmission equipment and production process equipment can be connected in real time, and at the same time, high reliability and low delay ensure the stability and timeliness of data transmission. And provides a guarantee for accurate long-distance operation.

4. Process production is dehumanized

From the history of the development of human manufacturing industry, taking the labor object as the guide line, the role played by human beings in the manufacturing process gradually moves backward, from manual production to manual operation of machine production, and

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then to computer control of machine tool production. The proportion of machines in the production workshop is getting higher and higher, and people are gradually withdrawing from the production process, production line and even the production workshop. In this paper, this phenomenon is called dehumanizing development of process flow system, and the development of human manufacturing technology is divided into four stages based on the role played by human in the production process.

The first stage is before the first scientific and technological revolution. At this time, there is no machine, and human beings directly participate in production. The main production tools are intuitive hand tools, which are usually anthropomorphic bionic structures and have the ability to expand and extend human basic abilities (such as strength). The characteristics of manufacturing technology in this period are: labor objects and processing tools are taken directly from nature, and the processing method is simple. Human beings basically use manual labor to process labor objects directly, and the amplification of labor ability by labor tools is very small.

The second stage began in the 1760s, when the first technological revolution began to introduce machinery into human production activities, the production mode changed from manual manufacturing to machine manufacturing, and the production tools gradually changed from anthropomorphic intuitive tools to abstract non-intuitive tools. The structure of tools was no longer based on human strength, and the design and manufacture of tools began to ignore structure and pay attention to function, and tools changed from amplifying people's basic ability to replacing people's ability. During this period, the human activities in the production line began to change, and some people gradually stopped processing the labor objects directly, instead, they operated the machines by hand, and the machines transformed the labor objects, and the role of human beings in the production line began to move backward. Productivity no longer depends on manual labor, but on machine labor with steam and electricity as the main power. At this stage, the mode of production is gradually complicated, and the amplification of labor ability by labor tools has made a qualitative leap.

The third stage began in the late 1970s, when computer technology began to be applied to manufacturing, and human production activities began to "remove the process and leave the results", that is, workers did not participate in the manufacturing process, but only participated in the setting of the results. During this period, the human role moved backward again, using programmed computer programs or directly manipulating computers to control the processing process in the production site, and the production was gradually automated, the production level of unit labor was getting higher and higher, and the productivity basically depended on the machine manufacturing level. Representative production methods include: lean manufacturing, advanced manufacturing, agile manufacturing and so on.

With the development of communication technology, Internet of Things technology and artificial intelligence technology, 5G leads mankind into the fourth stage-intelligent manufacturing stage, and the whole production process of products is completed by intelligent production lines. During this period, the manufacturing process was intelligent. With the support of sensors and industrial Internet of Things, human beings basically quit the production workshop, and remotely supervised and controlled the machines and equipment running in the workshop directly in the production dispatching center and control center. Moreover, the machines and equipment themselves had self-organizing ability, and the devices were interrelated through the industrial Internet of Things, which made the production process proceed in an orderly manner.

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5. Application scenario of 5.5G technology in intelligent process flow

5.1. Optimization of production process

The industrial Internet of Things changes the manufacturing industry by optimizing the production process, integrating multi-functional cooperative robots, intelligent production equipment and 5G-ai vision machines into the production process, and building intelligent production workshops based on 5G network technology. In the production process, the intelligent machine engaged in the operation can quickly obtain the required information through the 5G network, select the corresponding production mode according to the information content, and transmit the raw material demand information to the automatic material storage and transportation robot, so as to complete the rapid replacement of production materials and avoid the waste of production resources.

5.1.1. Additive manufacturing (3 d printing)

Traditional production mode is mainly based on "material reduction manufacturing", that is, workers or machines cut and cut raw materials according to the shapes required for production, so as to remove redundant scraps. Although this production mode can well meet the needs of the next production for material shapes, it inevitably causes a lot of waste of resources. In the intelligent process flow in the 5G era, the production mode has gradually changed to "additive manufacturing", that is, using 3 d printing technology, based on the digital model files such as the parameters of the required products or workpieces, the powdery and liquid bondable materials are printed layer by layer to construct objects. This mode of production can avoid material waste to the maximum extent and save resources for enterprises and society. The 5G network supports remote input of 3 d printing parameters, adjustment of equipment, organic connection of discrete 3 d manufacturing systems (different printing environments, different printers), seamless integration between different processes, truly realizing humanized production and providing infrastructure for the industrialization of 3 d printing technology.

5.1.2. Flexible production

Flexible production refers to the highly flexible manufacturing equipment based on computer numerical control machine tools to realize multi-variety and small batch production methods. Flexible production has become a new development trend because it can respond quickly to changes in market demand. Although it was put forward earlier, how to realize real flexible production has always been a difficult problem for scholars from all walks of life to discuss.

In recent years, in order to improve the production rate, enterprises have invested more and more machines and equipment in the assembly line, which on the one hand improves the integration of the workshop, but on the other hand makes the equipment control extremely complex and reduces the flexibility of equipment production. With the industrial application of 5G network, the equipment on the production line can get rid of the constraint of fixed cables, and the equipment can be connected through 5G wireless network, thus realizing the free movement, disassembly and combination of the equipment and realizing the flexible transformation of the production line in a short time.

5.1.3. Mass customized production

In the past, the profits of enterprises were mainly realized by continuously reducing the unit manufacturing cost of products through large-scale mass production. Nowadays, consumers' demands are becoming more and more diverse and changing faster and faster. If enterprises focus on mass production, it will be difficult to meet the ever-changing demands of consumers, and it is very likely to produce a large amount of inventory and even lead to bankruptcy.

In the traditional physical production mode, the whole process from product design, model, sample to finished product is formed by physical objects. Once there are changes, it is necessary to modify all drawings, models and samples from scratch, which not only consumes property,

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but also consumes time and energy. In the intelligent process flow, the production and manufacturing of products is a process of integration of reality and reality. The production preparation, design drawings and manufacturing models of products are all online "real" objects. Customers can experience products through virtual reality technology and modify them at any time according to their own preferences. The modification cost is low and the flexibility of production is greatly improved. 5G network provides the possibility of stable communication between enterprises and many customers, and the huge capacity can make many people operate online at the same time, so as to realize mass customized production of manufacturing enterprises.

5.2. Equipment monitoring and management

5.2.1. Implementation principle of equipment monitoring

Traditional equipment monitoring requires managers to inspect, supervise, command and control the equipment at the production site, so as to avoid failure affecting the production schedule. Nowadays, sensors and intelligent IOT control system are introduced into the production workshop. Based on 5G communication network technology, managers can know the data environment of production equipment in time by analyzing the data collected by sensors, including meteorological data, geographic data, operation data and fault data, etc. By analyzing the operation status data, managers can conveniently know the actual operation status of each equipment on site, quickly locate the fault equipment and realize remote real-time monitoring of production equipment.

As the key to realize the industrial Internet of Things, sensors are like monitoring glasses, which are mainly responsible for "monitoring". It can sense and record the information that needs to be measured, and transform the information into data that can be transmitted and identified according to certain rules. According to production needs, sensors can be divided into temperature and humidity sensors, light intensity sensors, infrared sensors, gas concentration sensors and other categories, which are used to sense the running state of equipment in all directions. The controller is like the arm of the monitoring system, which is mainly responsible for "control". It can receive the information released by the remote platform and convert the information into instructions that can be recognized by the equipment. Usually, a production workshop consists of multiple production systems, and each production system contains equipment with different division of labor, and each equipment is equipped with an identifier and a controller with corresponding perception. The physical networks between devices are separated from each other, but belong to the same virtual network-remote platform.

5.2.2. Specific functions of equipment monitoring

Based on specific functions, the application of Internet of Things in equipment monitoring and management can be divided into the following aspects:

Real-time positioning: the position of equipment can be determined at any time according to RFID tag, identifier position and recognition situation, so as to prevent the deviation of equipment position from affecting product quality and production progress, and the production task can be planned in advance according to the position of the conveying machine.

Remote control: the machinery and equipment located in the workshop are connected with the production management personnel at a long distance through the industrial Internet of Things, and the management personnel realize the remote control of the production site through the terminal platform and adjust the production status at any time.

Equipment monitoring: the production and operation parameters of machines and equipment, such as vibration, temperature, filling state of materials, etc., can be collected by sensors, so as to know their production status and whether they are in normal operation at a long distance.

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Failure reporting: predict the failure of industrial equipment according to the data collected in real time, so as to prevent accidents such as product quality damage caused by emergency and production tasks hindered by shutdown. When a certain module of the production system fails, the management platform can integrate relevant information in time, analyze the failure and take the next step automatically, so as to minimize the failure loss and maintenance cost.

5.3. Safety Production Management

Automation has enabled the machine to complete most of the work, but there are still a few production scenarios, and only people can correctly evaluate the decision according to the actual situation. Therefore, for some special scenarios, some people must participate in the production work. The traditional wi-fi network can meet the needs of video transmission, but its defects are also obvious: the transmitted video has low definition and long transmission time. When the video is transmitted to the application, the ever-changing scene environment is likely to have changed in the next step, so it can't meet the needs of manufacturing for video transmission at all, and can't realize remote monitoring. Different from the traditional field participation, 5G can ensure the ultra-clear field environment and ultra-low delay transmission. Managers can use AR glasses, wearable devices, intelligent robots and mechanical arms to remotely operate the production line, avoiding employees from directly participating in dangerous operations, ensuring their life safety and realizing safe production.

People and machines have different adaptability to physical environment. People can't carry out production activities in special environments such as high temperature, low temperature, high pressure, low pressure and lack of oxygen for a long time, but machines can. According to the needs of production environment, in the manufacturing process of robots or mechanical arms, the tolerance of machines can be greatly improved by using special materials.

Taking safety production in coal mine industry as an example, because the mine is dark and narrow, the environment is complex, the mining face moves at any time and the geological conditions change at any time, the machine cannot automatically take the next step according to the real-time situation, so people need to direct the production activities at the production site. However, it is difficult to ventilate and the gas concentration is high in the mine, so gas explosion accidents often occur, and once the explosion accidents happen, it will bring serious harm to the safety of employees. With the development of 5G communication network technology, remote sensing and control of mines can be realized by using Internet of Things technology and sensor network, and the safety of employees' lives and enterprise property can be guaranteed to the greatest extent. First of all, the sensors can accurately sense the personnel position, equipment status, gas concentration, pressure and other environmental conditions in the mining area in real time, adjust the production status and personnel position, and prevent danger. Secondly, through the visual machine and 5G transmission network, it can help managers understand the production environment in the field comprehensively and clearly, and help them make the next decision. Finally, through the industrial Internet of Things technology, it is possible to remotely operate machines and equipment, and let machines with high tolerance replace people to complete production work, thus truly realizing production dehumanization and safe production.

5.4. Product quality management

With the development of economy and the improvement of science and technology, consumers pay more and more attention to the quality of products. It can be said that the quality of products is the life of enterprises. The development of 5G network technology has given new possibilities to product quality monitoring. Through the combination of new technologies such as visual machine 5G wireless network, artificial intelligence and edge computing, the whole process quality management of product manufacturing can be realized, the operation can be

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adjusted according to the specific conditions of products in each production stage, and timely remedy can be made to achieve the purpose of reducing rejection rate.

5.4.1. Process diagnosis and intelligent repair

All kinds of sensors distributed in the production workshop and production line can obtain the data of each stage of the production cycle in real time, check the process quality by analyzing the data, evaluate whether the capability of each process meets the requirements of producing qualified products, achieve the purpose of process quality diagnosis, and realize the whole-process high-precision management of product quality. When the sensor detects that the raw materials, temperature and pressure are abnormal, the system will automatically stop the production activities, and the corresponding controller switch will be turned on to adjust the process environment to meet the production requirements. When all parameters return to normal range, the system resumes production activities, so as to minimize the generation of waste products from the source.

5.4.2. Product screening

When the finished product passes through the conveyor belt, the HD camera can take photos from all directions, and the deep learning machine can be used to read the pictures and check the product quality, and the mechanical arm can screen out the unqualified products. According to statistics, by using "5G+artificial intelligence vision machine" instead of manual inspection, the per capita output can be increased by two times, and every product produced can meet the quality standards.

6. Conclusion

This paper analyzes the inevitability and development trend of intelligent manufacturing in the 5G era, analyzes the changes brought by the development of 5G related technologies to industrial manufacturing, and explores the application scenarios in detail.

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