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Research on the Application of Digital Twinning in Intelligent Manufacturing

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Abstract: At present, the remarkable improvement of China's comprehensive strength is inseparable from the support of intelligent manufacturing. Its implementation of intelligent manufacturing related work around the content of "talent-oriented" not only meets the requirements of China's industrialization strategy development, but also leads China's manufacturing industry to the mainstream. The application effect of digital twinning technology in the field of intelligent manufacturing is good, especially in the complex intelligent manufacturing process, digital twinning and multi-agent technology can play a full role, which can not only significantly improve production efficiency, but also prevent poor quality, which is of great significance to reduce energy consumption and waste products. Taking the connotation and characteristics of digital twinning as the breakthrough point, this paper expounds the application points of digital twinning in the field of intelligent manufacturing, and makes a comprehensive discussion on the research progress and future development trend.

1. Introduction

The society as a whole has entered a new development state, and the Ministry of Industry and Information Technology has paid more and more attention to the digital transformation of manufacturing industry, and jointly issued the "14th Five-Year Plan for the Development of Intelligent Manufacturing" with other departments in action, which is of great significance for accelerating the development of China's manufacturing industry and has become an important guarantee for the digital transformation and intelligent transformation of manufacturing industry. In the process of intelligent manufacturing, intelligent production line is taken as the main carrier, artificial intelligence technology. The advanced manufacturing technology are integrated, revolutionary changes which are formulated and implemented. The digital twin technology is mainly applied to production workshops, intelligent factories and intelligent production lines, which significantly improves the effect of intelligent manufacturing. We need to ensure that the corresponding enterprises occupy an important position in the fierce competitive environment.[1]

2. Overview of "Digital Twin"

By analyzing and summarizing the content of "digital twinning", we will find that it is a technology to digitize physical entities. During the simulation of actual physical processes, we rely on the construction of virtual digital twinning model to ensure that the details of simulation, data analysis and optimization design are carried out in an orderly manner. During the development of intelligent manufacturing, great attention was paid to the application of digital twins. The main features and innovations are reflected in many aspects, as follows.[2]

First, the characteristics of automation and intelligence are remarkable. For intelligent production line, automation equipment and intelligent system are the main supports to ensure the smooth operation of intelligent control and intelligent decision-making during production. This can not only save labor costs, but also improve production efficiency and quality. Second, the effect of virtual verification and prediction is good. With the aid of simulation technology, verifying and predicting the actual situation of the construction scheme of intelligent production line in virtual environment is conducive to finding and solving potential problems in time and plays an important role in reducing the risk rate. Third, it can be iterated and optimized more quickly, and the production cycle of the product can be reasonably shortened after the simulation technology and the efficient production line construction scheme give full play.

3. Application of Digital Twinning in Intelligent Manufacturing

3.1 Application in production workshop

Based on the analysis and research of the actual situation of the previous production workshop, we know that worker management is an important basis to ensure the orderly development of the production work in the workshop. When recording information, statistical data, querying various contents and analyzing data, we rely on manpower. In this case, the probability of data quality failing to meet the standard is high, and even the problem of not being able to accurately grasp the actual production situation in the workshop in time is caused. Although the systematic and digital management methods are emphasized in the follow-up, there are still cases where the actual workshop and the virtual workshop cannot interact and blend in real time. In this case, building a "digital twin workshop" based on digital twin technology mainly refers to scientifically and reasonably integrating every process and business data involved in physical real space and virtual space, and perfecting the existing physical workshop production process and related requirements with the help of twin data and workshop twin model, which is actually a very key workshop production mode. The application of digital twin technology in the workshop can not only improve the production efficiency and quality, but also form a new workshop production and operation mode with high application value.[3]

3.2 Application in Intelligent Factory

Zheng Xiaohu and Zhang Jie [1] studied the application of digital twin technology in the process of solving problems, and at the same time, combined with the challenges faced during the production of fabrics, formulated targeted solutions. For example, the whole process of intelligent assembly production line includes MES ordering, warehousing raw materials, AGV trolley, intelligent robot assembly, finished product warehousing and other links, and on this basis, a highly targeted intelligent assembly workshop model is determined. The Industrial control system determine the information of the current state of each part, the process involved during transmission, manufacturing steps and other intelligent units, highlight the characteristics of assembly intelligent

engineering, show the application advantages of digital twin technology, ensure the implementation of the construction of intelligent assembly virtual workshop, and create conditions for subsequent operations such as self-analysis and self-decision.[4]

3.3 Application of intelligent production line

At present, the application of digital twin technology in intelligent production line has attracted much attention, among which the typical representative is the application in aero-engine intelligent production line. After careful analysis, it will be found that the production steps of aero-engine are very complicated, and the previous design and research and development work must be repeatedly tested under extreme conditions. Cui Yihui, Yang Bintao, Fang Yi [2] and others have identified the problems that need to be solved urgently in the design process of aerospace engines, and learned that they are mainly reflected in many aspects, such as high cost and long development time. Subsequently, they have formulated and implemented a virtual entity construction plan according to the needs, which is embodied in the efficient construction of virtual entities based on digital twinning technology, paying special attention to its proportion with physical entities. In addition, in order to ensure that the structural strength and performance results of the whole machine and parts obtained after analysis are true and effective, the simulation software is applied to save more research and development costs.

4. Research progress of digital twins in the field of intelligent manufacturing

During the development of intelligent manufacturing field, the application of digital twin technology was attached great importance. In order to solve practical problems, the space modeling of intelligent manufacturing was emphasized. Kleanthis clearly pointed out in his research article that the UML model extraction of system software is implemented in SysML system model, and then the code is refined according to the specific requirements to ensure that the two schemes play a role in the application of PLC and embedded boards in the market.

In addition, Wang Tianran also conducts research in combination with the corresponding content, which follows the pace of the current information technology reform work, clearly points out the spatial characteristics of intelligent manufacturing in many aspects, and flexibly distributes after meeting the requirements of unification of decentralization and centralization; Inefficiency cannot occur, and at the same time, it is necessary to meet the individual needs to the greatest extent; During the design and manufacture, it meets the requirements of the combination of reality and reality. With the help of virtual space simulation experiments, the operation of design verification and modification tasks can be completed more quickly. Zhang Chen yuan[3] proposed a new five-dimensional digital twin modeling method. During this period, the manufacturing system was taken as the basic guarantee, and the physical twin and the virtual twin were mapped after it was brought into full play, and the corresponding functions were derived and determined to have strong dependence. The expandable model structure formed and applied in this way has high application value. At the same time, the perfection of the digital twin manufacturing system was improved, and the reconstruction scheme was formulated and implemented according to different goals and different granularity.

The application of digital twin technology has obvious advantages, which is suitable for intelligent manufacturing, and provides a feasible scheme for the digital transformation of related enterprises. With the help of simulation experiments, the behavior in the real environment is simulated, and after understanding the real needs, the operations of building scenes and adding objects are ensured to be carried out in an orderly manner. In the future, the field of intelligent manufacturing will be in a state of long-term and stable development, and more attention will be

paid to the research and development and application of digital twin technology, and the performance of production lines will be evaluated and optimized, so as to further save more resources and funds and create more benefits.

5. Conclusion

At present, the model and structure of digital twin technology are constantly improving, and will be gradually expanded in the future, which is conducive to improving the productivity in the field of intelligent manufacturing and creating conditions for promoting the stable development of the overall economy in the future. In the development of intelligent manufacturing, digital twin technology is applied efficiently, and advanced implementation schemes are formulated and implemented according to the requirements of intelligent production, highlighting the application advantages in many aspects, making up for the shortcomings of previous production methods, truly improving the efficiency and quality of intelligent production and promoting the intelligent development of production lines, workshops and factories.

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References

[1] Zheng Xiaohu, Zhang Jie. Application of digital twin technology in textile intelligent factory [J]. Textile Herald, 2019, (03): 37-41.
[2] Cui Yihui, Yang Bintao, Fang Yi, et al. Application of digital twinning technology in aero-engine intelligent production line [J]. Aeroengine, 2019, 45 (05): 93-96.
[3] Zhang Hao. A Digital Twin-Based Approach for Designing and Multi-Objective Optimization of Hollow Glass Production Line [J].IEEE Access, 2017 (5): 26901 ~26911.