ISSN 2616-5767 Vol.4, Issue 2: 38-44, DOI: 10.25236/AJETS.2021.040206

Research on Mechanical Design and Manufacture Based on Multi-Agent and Its Automation Application

Chunyang Wang*, Fumin Zhu

Shanghai Maritime University, Shanghai 201306, China
**Corresponding author: cywang012@163.com*

Abstract: *As far as China's current economic development is concerned, economic development depends heavily on machinery manufacturing. Machinery manufacturing has provided great help for China's economic development, but the traditional machinery design and manufacturing can no longer meet the requirements of social development in the new era. For traditional mechanical design and manufacture, there has also been a historic change. The impact of new technical methods on traditional mechanical design and manufacture has also promoted the development of mechanical design and manufacture towards automation, which has become a mainstream trend of mechanical design and manufacture at present. In this paper, the theme of mechanical design and manufacture and its automation application based on multi-agent is discussed. Firstly, the background of this paper is briefly introduced, and then the advantages of mechanical design and manufacture and its automation application are analyzed. Then, the application of automation technology in mechanical manufacturing process is analyzed from different aspects, and the future development is prospected.*

Keywords: *Multi-self-subject, Mechanical design and manufacture, Automatization*

1. Introduction

With the development of science and technology, the degree of mechanical automation is constantly improving. The application of automation technology has greatly improved the working efficiency of mechanical equipment, and also improved the accuracy of mechanical equipment task completion. The development of mechanical design and manufacturing and its automation technology not only improves the production efficiency and reduces the labor force, but also improves the safety of workers and reduces potential safety hazards. At the same time, it is also convenient for the maintenance of machinery. Therefore, it is of great significance to discuss the application advantages and development trends of mechanical design and manufacturing and its automation [1].

As far as China's current economic development is concerned, economic development has great dependence on machinery manufacturing. Machinery manufacturing has provided great help for China's economic development, but the traditional machinery design and manufacturing can no longer meet the needs of social development in the new era [2-3]. Consistency of multi-agent system means that each individual in the multi-agent system moves according to the pre-designed static or dynamic control laws or algorithms. With the passage of time, some key quantities of all individuals in the system are unified, so that they can complete specific tasks or achieve certain goals that researchers want. Therefore, it is the only way for industrial design reform to combine mechanical design and manufacturing automation applications based on multi-agents.

2. Theoretical overview and analysis of mechanical design and manufacture and its automation

For mechanical design, manufacture and automation, it is mainly to apply automation technology to mechanical manufacturing enterprises, which can realize the continuous production, improvement and optimization automation of the processed objects, and then mechanical manufacturing automation is applied to actual production [4]. This also plays a very important role in today's economic development. The realization of mechanical design and manufacture and its automation is also an important direction in the development of mechanical design and manufacture. Improvement through automation can make mechanical design and production more intelligent and humanized, and also play a very important role

ISSN 2616-5767 Vol.4, Issue 2: 38-44, DOI: 10.25236/AJETS.2021.040206

in promoting the development of mechanical manufacturing industry in the future.

The application of mechanical design and manufacturing automation can not only maximize the functions of machinery, but also improve and enrich the functions of machinery, and ensure the quality of manufactured mechanical products with high precision. The working parameters reflected in the process of mechanical manufacturing will have a direct impact on the final quality and quantity of mechanical products. Therefore, the stable control of the parameters in the workflow can provide a powerful guarantee for the good implementation of mechanical design and manufacturing automation.

3. Advantages of mechanical design and manufacturing and its automation application

3.1 Conducive to improving production efficiency

Mechanical design, manufacture and automation can change the traditional manual operation mode, so that on the one hand, the production efficiency can be improved. After all, the efficiency of mechanical work is much higher than that of manual work. On the other hand, the labor input and labor force are reduced, and the number of employees in enterprises is naturally reduced, thus reducing the cost of human resources and improving the economic benefits of enterprises.

In addition, errors are easy to occur in the process of manual operation, and once errors occur, the loss of enterprises increases, which is equivalent to virtually increasing the cost of enterprises. Now, it is replaced by mechanical operation, which reduces the loss, which is equivalent to realizing cost savings, thus ensuring the improvement of economic benefits of enterprises and promoting the sustainable development of enterprises [5].

3.2 Conducive to the adjustment and maintenance of machinery

In the traditional working environment, both the inspection and maintenance of machinery need to be completed by manual force. Some employees have poor sense of responsibility, and the inspection of machinery is not very serious, which leads to many mechanical failures but is unclear. As a result, a lot of losses will occur, and the personal safety of employees will also be threatened. Under the application of mechanical design, manufacture and automation, the inspection for faults can be adjusted and checked by external equipment. After problems are found, relevant machinery will send out alarm signals at the first time, which can ensure everyone's personal safety. At the same time, it can also improve the working efficiency. Most importantly, we know that machines, like human beings, have a long life. Timely maintenance can prolong the service life of machines, and then achieve cost savings, which can be said to serve multiple purposes.

3.3 Ensure operation safety

During the development of manufacturing industry, there are many potential safety hazards, and some industries with low safety factor and high risk even directly threaten the personal safety of employees. With the help of automation technology, many high-risk jobs can be completed by means of mechanical manufacturing. On the one hand, mechanical manufacturing can improve work efficiency; on the other hand, such a way can improve safety factor and ensure recognized personal safety, which is beneficial to both employees and enterprises [6]. At the same time, the personal safety of employees is also related to the cost control of enterprises. If employees have a safety accident, it will not only damage the reputation of enterprises, but also compensate a lot of expenses, thus causing economic losses. Therefore, it is of great significance to realize the development of mechanical design and manufacture and its automation.

4. Advantages of mechanical design and manufacturing and its automation application

4.1 Conducive to improving production efficiency

Mechanical design, manufacture and automation can change the traditional manual operation mode, so that on the one hand, the production efficiency can be improved. After all, the efficiency of mechanical work is much higher than that of manual work. On the other hand, the labor input and labor force are reduced, and the number of employees in enterprises is naturally reduced, thus reducing the cost of human resources and improving the economic benefits of enterprises.

ISSN 2616-5767 Vol.4, Issue 2: 38-44, DOI: 10.25236/AJETS.2021.040206

In addition, errors are easy to occur in the process of manual operation, and once errors occur, the loss of enterprises increases, which is equivalent to virtually increasing the cost of enterprises. Now, it is replaced by mechanical operation, which reduces the loss, which is equivalent to realizing cost savings, thus ensuring the improvement of economic benefits of enterprises and promoting the sustainable development of enterprises [7].

4.2 Conducive to the adjustment and maintenance of machinery

In the traditional working environment, both the inspection and maintenance of machinery need to be completed by manual force. Some employees have poor sense of responsibility, and the inspection of machinery is not very serious, which leads to many mechanical failures but is unclear. As a result, a lot of losses will occur, and the personal safety of employees will also be threatened. Under the application of mechanical design, manufacture and automation, the inspection for faults can be adjusted and checked by external equipment. After problems are found, relevant machinery will send out alarm signals at the first time, which can ensure everyone's personal safety. At the same time, it can also improve the working efficiency. Most importantly, we know that machines, like human beings, have a long life. Timely maintenance can prolong the service life of machines, and then achieve cost savings, which can be said to serve multiple purposes.

4.3 Ensure operation safety

During the development of manufacturing industry, there are many potential safety hazards, and some industries with low safety factor and high risk even directly threaten the personal safety of employees. With the help of automation technology, many high-risk jobs can be completed by means of mechanical manufacturing. On the one hand, mechanical manufacturing can improve work efficiency; on the other hand, such a way can improve safety factor and ensure recognized personal safety, which is beneficial to both employees and enterprises [8]. At the same time, the personal safety of employees is also related to the cost control of enterprises. If employees have a safety accident, it will not only damage the reputation of enterprises, but also compensate a lot of expenses, thus causing economic losses. Therefore, it is of great significance to realize the development of mechanical design and manufacture and its automation.

For a moving multi-agent system, the system contains n individuals, and the velocity vector of individual i at time t is recorded as $v_i(t)$, which means that the system velocity is consistent. If $\forall_\varepsilon > 0, \exists_{t_c} > 0, s.t \quad \forall_t > t_c$, for any $i, j \in \{1,2,\cdots,n\}, i \neq j$, there are

$$\left\| v_i(t) - v_i(t) \right\|_p < \varepsilon \tag{1}$$

In which $\left\| \cdot \right\|_p$ is the p-norm of the vector.

The multi-agent system and its behavior at the group level can be attributed to the following three elements:

1) Dynamic individual

2) Communication network topology of information exchange between individuals

3) The reaction rules of individuals after receiving information from other individuals, that is, control protocols

In the multi-agent system, the mechanism of random edge connection based on individual state information is adopted, and then the communication network topology structure of the system at each moment is formed.

5. Application of automation technology based on multi-agent in mechanical manufacturing process

5.1 Technology integration of electromechanical automation and mechanical manufacturing process

The integration of electromechanical automation and mechanical manufacturing process is the main application embodiment of automation technology. Specifically, the integration of electromechanical

ISSN 2616-5767 Vol.4, Issue 2: 38-44, DOI: 10.25236/AJETS.2021.040206

automation and mechanical manufacturing process involves mechanical maintenance, repair and identification.

For a reference individual, all other individuals in the system are labeled according to their distance from the reference individual. The nearest label is small, and the distant label is large. The neighbor selection probability in the model can show that the near individual has a high probability of being selected as a neighbor by the reference individual, while the far individual has a low probability of being selected as a neighbor by the reference individual.

As for fig. 1, since an individual chooses neighbors according to the connected edge probability, when an individual i chooses an individual j as his neighbor, the individual j does not necessarily choose an individual i as his neighbor, and this neighbor relationship is also asymmetric.

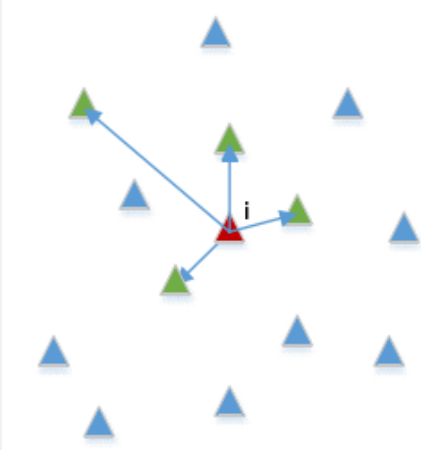

Figure 1: Choose neighbors according to probability

In order to specifically quantify the possibility that individual i receives individual j as his neighbor at each time, we use connected edge probability $p_{ij}(t)$ to express the probability that individual j becomes the neighbor of individual i at time t, and $p_{ij}(t)$ is obtained by normalizing $w_{ij}(t)$, and its expression is as follows [9]:

$$p_{ij}(t)=\frac{e^{-\alpha d_{ij}(t)}}{\sum_{k\neq i} e^{-\alpha d_{ik}(t)}} \tag{2}$$

$\alpha \in [0,\infty)$ is a random parameter used to adjust neighbor selection, which is called distance similarity factor. The greater α is, the greater the influence of location gap is, and the less random neighbor selection is. The smaller α is, the greater the influence of location gap and the greater the randomness of neighbor selection. When $\alpha = 0$, the neighbor selection is completely random, and the neighbor selection probability is a constant, that is, $p_{ij}(t)\frac{1}{n-1}$, and the individual i chooses k other individuals as its neighbors with equal probability.

In the management of mechanical equipment, technicians need to regularly check the running status of equipment, find problems and repair them in time, so as to ensure the safe and stable operation of mechanical equipment. Technical identification can be used to analyze and identify the fault information in production, and then the fault information needs to be uploaded and saved for reference in the later maintenance of mechanical equipment. With the deepening application of electromechanical automation technology in military and medical fields, miniaturization technology and automation technology can be further integrated, so that the mechanical products designed and manufactured have the characteristics of small size, flexible application and low energy consumption, and the application effect of automation technology can be continuously improved.

ISSN 2616-5767 Vol.4, Issue 2: 38-44, DOI: 10.25236/AJETS.2021.040206

5.2 Information automation

Electronic computer technology and automatic production have a deep origin, and they coexist. With the integration and development of network communication technology and computer technology, the development space of automatic production also increases. At present, China's machinery design and manufacturing industry should pay attention to the role of computer and network technology, and use computer software technology to simulate the manufacturing and operation of machinery, so as to form an effective control over the whole production, and find out the shortcomings and correct them in time.

Virtual machine tool is the direct control object of NC machining simulation system, and the user's operation will finally reflect the movement of virtual machine tool and the machining of virtual workpiece. The essence of building and controlling virtual machine tools is to determine the model structure, loading method and control mode of virtual machine tools, and to build virtual machine tools that meet the requirements. The following points must be considered in the construction of virtual machine tools: first, ensure the accuracy of motion; Secondly, the reproduction performance of machine tool structural parameters is good; Third, ensure the assembly accuracy among the assembled parts; Fourth, strictly control the movable direction of moving parts; Fifth, the established machine tool model must be driven conveniently; Sixthly, the model data should be reduced as much as possible without affecting the reality of simulation [10]. See fig. 2.

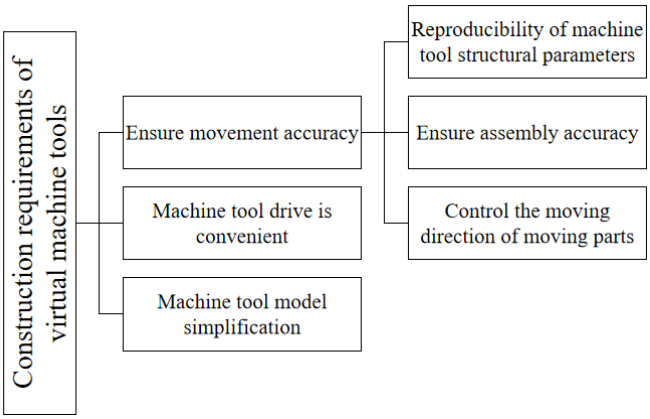

Figure 2: Virtual machine tool construction requirements

The machine tool is a product of modular design, which can be designed and manufactured separately and assembled into a whole machine through standardized interfaces. Taking the workbench module as an example, the workbench module divided here includes not only the traditional workbench design module, but also the ball screw nut mounting flange, ball screw nut, slider and its accessories, oil path and oil port accessories, water baffle and other structures. Introducing the "return-to-zero method" model into method can well solve the problem of model assembly accuracy [11]. "Zero-return method" means keeping the origin of coordinate system of all component model databases at the same position, instead of the center of their maximum envelopes. After these models are imported into VP, according to the VP import mechanism, the coordinate system will coincide with the VP world coordinate system, so that all component models are located at the zero point of VP world coordinate system after initialization. See figure 3. Thereby ensuring accurate relative positions when all components are introduced.

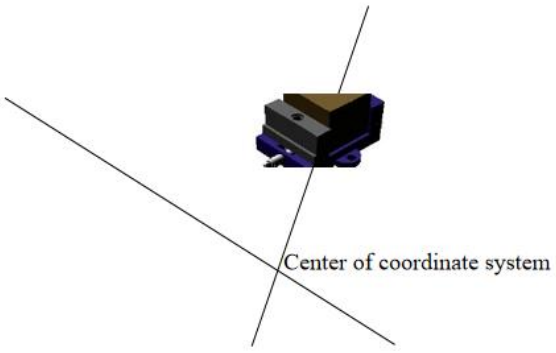

Figure 3: The origin position of the model constructed by "return to zero"

ISSN 2616-5767 Vol.4, Issue 2: 38-44, DOI: 10.25236/AJETS.2021.040206

Computer-aided system is the key form to complete automation in mechanical manufacturing and automation. Computer-aided system contains and involves a wide range of contents, including computer aided process design system and computer aided design system. This is also the core part of the application of computer technology in mechanical manufacturing. For example, some simulation technologies can be ideally applied to the process of mechanical production, so as to achieve the final design effect. Visualization technology can control the problems in the past operation of technology manufacturing, improve the production efficiency, make the designed products more secure, and even if there are problems, they can be handled in the most timely manner.

5.3 Application of flexible automation technology

The application of flexible automation technology in mechanical manufacturing mainly depends on the development of computer technology. In the process of mechanical manufacturing, flexible automation technology is mainly used in some technical operation links. With the support of this technology, it can promote the efficient production activities of mechanical manufacturing and greatly reduce the production cost.

Digital control system plays a connecting role in the whole machining simulation system, and it is also the core of the whole machining simulation system. In virtual reality machining simulation system, the function of digital control system is to realize the accurate movement of virtual machine tool according to user's instructions (NC code or manual operation). Digital control system needs to have three parts: module for processing demand instruction, module for transmitting user instruction and module for driving virtual machine tool. The modules are named as instruction analysis module, intention transfer program module and drive module respectively. As shown in fig. 4.

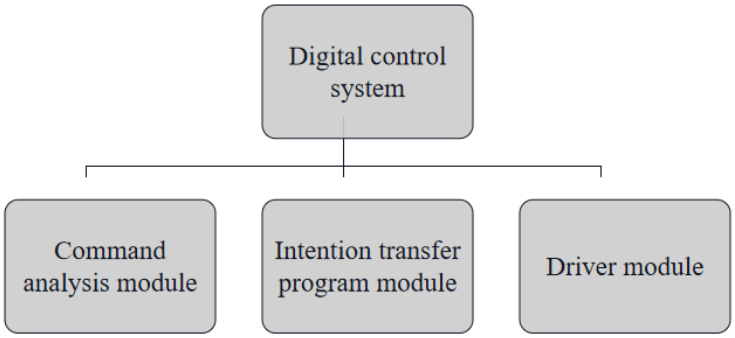

Figure 4: Composition of digital control system module

In view of the development of mechanical manufacturing activities and the application of automation technology, the labor pressure of manpower is greatly relieved, which provides a good guarantee for the life and health of workers. With the help of digital control technology, through the effective use of computer technology and equipment, mechanical automation can be effectively promoted, thus effectively promoting the development of China's mechanical manufacturing industry. With the support of flexible automation technology, not only the mechanical production efficiency is improved, but also the product quality is guaranteed more.

6. Analysis of the development trend of future mechanical design, manufacture and automation

According to the analysis of China's industrial strategic development at present, the future metal development of mechanical design and manufacture automation will look at the development direction of mechanical design and manufacture automation from the perspective of sustainable development strategy, and make it develop in the direction of green and modularization.

As for the development direction of virtualization, it is mainly through computer technology to carry out some virtual operations on mechanical design, make corresponding analysis on data, and make advance prevention for possible problems in future design and manufacture, which also directly reflects the development of mechanical design and manufacture and its automation towards virtualization. Modularization involves more parts needed in mechanical design in the future. In order to facilitate management, the difficulty of research and development is simplified, and it is studied in a modular way. Networking is the informationization in the process of mechanical design and manufacturing, and the

ISSN 2616-5767 Vol.4, Issue 2: 38-44, DOI: 10.25236/AJETS.2021.040206

technology will involve some network resources, which is also the key to improve the competitiveness of mechanical design and manufacturing.

7. Summary

China is a big manufacturing country, and the importance of manufacturing industry to China's economic development is self-evident, especially the design and manufacture of machinery and its automation application are related to the development direction of China's future manufacturing industry. The flexible application of mechanical design and manufacture based on multi-agent and its automation in electrical engineering plays an important role in improving production efficiency, controlling construction cost scientifically and reasonably, and promoting the rapid development of China's social economy. And its broad development prospects also require that we must increase the investment in science and technology, study the improvement of mechanical design, manufacture and automation technology, treat it as a key development issue, and constantly improve the application level of technology to promote the improvement of China's social and economic level.

References

[1] Sun Hongxia, Liu Zhao, Li Hongwei. Study on specialty characteristics of mechanical design, manufacture and automation in the new era. Metallurgy Series, Vol. 000 (2017) No. 012, p. 230-231.
[2] Xiang Li. Current situation reflection and prospect of mechanical design and manufacturing and automation specialty. Southern Agricultural Machinery, Vol. 049 (2018) No. 011, p. 89-89.
[3] Liu Tianzhan. Analysis of the development direction of mechanical design and manufacturing and its automation. Science and Technology Outlook, Vol. 27 (2017) No. 009, p. 66.
[4] Li Siyu, Hou Junji, Wang Heyun. Application Analysis of Computer Technology in Mechanical Design, Manufacturing and Automation. Southern Agricultural Machinery, (2019) No. 1, p. 121-121.
[5] Wu dongmao. Reflection on the present situation and prospect of mechanical design, manufacturing and automation specialty. Global market, Vol. 000 (2017) No. 024, p.104-104.
[6] Chen yuanhan. Reflection on the present situation and prospect of mechanical design, manufacture and automation specialty. Guangdong sericulture, Vol. 052 (2018) No. 004, p. 40-41.
[7] Wu Xin. My opinion on the development prospect of mechanical design and manufacturing and its automation. Business Situation, (2017) No. 15, p. 211.
[8] Chen Guoyu. My opinion on the development prospect of mechanical design and manufacturing and its automation. Modern Property (Zhongxunkan), Vol. 414 (2018) No. 02, p. 38-39.
[9] Ren Zhongyan. My opinion on the development prospect of mechanical design and manufacturing and its automation. SME Management and Technology, Vol. 000 (2018) No. 003, p. 190-191.
[10] Wang qingde, Wang Jingxin, Zhang fushan. Design and performance evaluation of automation equipment for plywood production line in woodworking machinery industry [J]. Management symposium, 2018:520-531.
[11] Zhang Lu, in Shui Xin, Liu Xinyue. Analysis of the development prospect of mechanical design and manufacturing and its automation. Women's Daily: Family Quality Education, (2020) No. 1, p. 0245-0245.