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Optimization design and motion simulation of multi-link mechanism based on mechanical press[1]

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Abstract. Multi-link mechanism of mechanical press has gradually become an important technology for the development of machinery industry in the current era. However, there are still many shortcomings in the theory and operation of this technology. The theory of multi-link mechanism of mechanical press in China was summarized and compared with the traditional presses. Mechanical horses were taken as examples, and the relevant major influencing factors were identified and optimized. The results show that the optimized mechanical horse is more stable. The purpose of this study is to provide scientific support for the improvement of the theory of multi-link mechanism of mechanical press in China and to provide a positive impact on the development of machinery industry in China.

Key words. Mechanical press, multi-link mechanism, optimization design, motion simulation
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1. Introduction

In the present era, with the rapid development of the world economy, science and technology has become an important productive force in the development of the times. It is very important for the development and promotion of various industries in the world. As the first productive forces in the economic development of the present era, the development of various kinds of science and technology is the inevitable demand of economic and enterprise development in the present era. It is also an important driving force for the development of a national or regional industry, which further combines with the traditional enterprise industry, so as to achieve the comprehensive improvement of a country or region. Nowadays, many

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industries have begun to introduce advanced science and technology step by step, and design more products which are suitable for the development of the times. These products have brought a very important influence on the development of the world and society. This study will mainly be based on the optimization design of multi-link mechanism of mechanical press and its application to motion simulation, so as to provide some theoretical basis or technical support for the development of some simulation products in China.

2. State of the art

With the development of economy, machinery industry has gradually become an important economic pillar industry in a country or region. The development of the machinery industry is of great importance to the promotion of the economic level of a country or region [1]. Especially the introduction and application of new related innovative technologies, which began to introduce more new mechanical theories into the development of mechanical design industry and bring a very important impetus to the development and progress of these industries, the continuous improvement of mechanical design theory and the development of technology make more mechanical products begin to be constantly designed, and the related design concept is constantly optimized, and the product performance is higher [2]. The related theory and design scheme of product design is one of the important production links in the design of mechanical products. Under the application of new design concepts and technologies, the design of today's mechanical products is more efficient and unified, which is more suitable for the needs of various mechanical facilities [3]. Multi-link mechanism of mechanical press which is designed by machinery in the modern times is a design concept with more design technology and first opportunity, which has the important development significance for the development of many industries.

The multi-link mechanism of mechanical presses can effectively promote the use of other industries and products because it has practical and more advanced technology, and its performance is better for other related equipment [4]. In many industries, the mechanical press multi-linkage mechanism has been gradually quoted. In particular, in the design of related products for motion simulation, mechanical press multi-linkage mechanism with more consideration for the application of disabled crowd simulation sports equipment can be further applied to assistive devices in disabled persons through the related products designed by this technology [5]. Many research scholars believe that because it can better simulate the movement of the normal population, this kind of sports equipment with simulation performance makes the design mode of the simulation sports equipment more rational and scientific, and further provides some technical support for further efficient use of related products, provides theoretical basis for the design and improvement of more related products [6].

3. Methodology

In today's era, with the continuous development of mechanical technology, the introduction of more and more new science and technologies has made many enterprises gradually pursue more precise related parts and accessories [7]. As the development of various industries makes a larger number of mechanical products parts began to be gradually demand, this trend has further promoted the development of machinery industry, making its industry-related technology and theoretical standards continue to enhance and improve, as a result, the economic strength of the present world is further enhanced (Fig. 1).

Since entering the new century, the continuous improvement and progress of economic level in China have made the comprehensive national strength of the country greatly improved and developed. Especially since the reform and opening to the outside world, the state has further introduced advanced technology from western developed countries. With the continuous improvement of comprehensive economic strength in China and the gradual increase of communication with the outside world, China's related products and technologies are gradually extended to other countries [8]. In this trend, China's various industries have a great degree of development. As an important pillar industry in China, the machinery manufacturing industry can provide some spare parts and assembly process for more industry development, so as to gradually increase its importance, further promote the further research and discussion of China's related theory and technology for the industry [9]. In the current era, more advanced technology has gathered the mechanical manufacturing technology, which has made great progress in the manufacture of machinery in our country, and has made great achievements. Since the new century, with the increasing importance of the industry in China, the machinery manufacturing industry has been further promoted and progressed. At the same time, the research on the theory and technology of the industry is more systematic and scientific. The degree of organic combination of production has gradually improved. However, the relevant technology and theory have been greatly improved. At the same time, some uncoordinated phenomenon is further exposed. It can be seen from the generalization of the times, although our country already has a lot of mechanical multi-linkage mechanism related technologies in the current era, many enterprises have continued the application of the traditional mechanical multi-link technology, and the application of the multi-link technology of the mechanical press is less. Even in many industries, the multi-link technology of mechanical press, which has a great advantage, has been gradually applied to the actual industrial development, due to the lack of understanding and cognition of relative theoretical knowledge of the technology, the algorithm of analysis is more using vector algebra or matrix method. These more backward analytical algorithms do not provide an accurate analysis of the relevant model, and further provide a degree of distress for subsequent mechanical programming and theoretical optimization [10]. These algorithms make the workload and work more difficult, which further limits their usefulness. The controllability of the design program is gradually reduced, so it cannot better meet the actual needs. In many enterprises, because the operation of the technology is more complex, the op-

erator is not proficient in the relevant technology, and the man-machine interaction cannot be more coordinated, so that the use and operation of multi-link mechanism of mechanical press in our country is still relatively backward. In view of this series of uncoordinated phenomena, the relevant theories and techniques of this technology need to be constantly optimized. It is of great importance to put forward relevant proposals which are more suitable for the operation of this technology. Especially in view of its complex operation and operation principle, it is an important trend for the development of this technology to optimize its related structure and optimize its related process [11]. The input and modification of the parameters of the visual working mechanism are difficult, and the man-machine interaction is poor. In view of this situation, this study mainly used the mechanical press multi-link mechanism as the object of study, and further analyzed and discussed the mathematical expressions of the relevant data indexes in the operation of this kind of running mechanism through reading the relevant data. On this basis, through the reference to relevant optimization methods, in this paper, a new multi-link press technology which is more suitable for the development of industry and field in modern times was further determined [12]. Finally, the relevant actual cases were introduced to analyze the obtained results to prove the accuracy of the research and conclusions. In our country, the related theory and technology of mechanical multi bar linkage technology is imperfect, and this study is mainly to further analyze its related characteristics. The purpose of this study is to provide theoretical basis for the development of related technologies in China and to provide some reference for the continuous improvement and promotion of the comprehensive strength and related theories of related industries in China, so as to provide scientific support for the development of China's comprehensive economic level.

Fig. 1. Development of China's machinery industry

The four-block single-drive mechanical mechanism design was taken as an exam-

ple. The design of the multi-link mechanism of the mechanical press and the related design scheme of the motion simulation were studied. Firstly, the relevant design scheme of the mechanical design was summarized and analyzed. The main design options included the choice of movement mode and drive mode. The summary results are shown in Table 1.

Table 1. Analysis of the design scheme of four legged single drive mechanical horse mechanism

Design level	Relevant requirements
Movement mode	1. Deduce kinematic equations conveniently
	2. With a certain strength and load capacity
	3. The control is simple, and the structure is easy to process
Drive mode	1. Motor drive
	2. Hydraulic drive
	3. Air pressure drive
Shape design	1. Long 879 mm
	2. Width 208 mm
	3. High 720 mm

Then, the simulation of the mechanical design was designed. The relevant model formula is shown below. After optimizing the machine, the mechanical design before and after optimization was analyzed and compared.

$$\theta_1 = 180 - \arccos \frac{OF^2+OA^2-2OF\cdot OA\cdot\cos\angle FOA+EA^2-EA^2}{2\cdot EA\cdot\sqrt{OF^2+OA^2-2\cdot OF\cdot OA\cdot\cos\angle FOA}}+ \\ + \arcsin\left[\frac{OF}{FA}\sin\angle FOA\right] - \angle EAB\,. \tag{1}$$

Here, OF and OA, respectively, represent the mechanical arm and link length; ∠ FOA represents the included angle formed by the mechanical arm movement, and EA represents the length error between different lengths of mechanical arm.

4. Result analysis and discussion

The related concepts and technologies of mechanical press multi-link are not relatively new concepts and techniques, which have been applied in our country for several decades, and have already entered our country's market emergency system construction earlier (Fig. 2). China's first research and description of related technologies and theories date back to the last century [13]. In 1950, in China, the company began to refer the related technology to its manufacturing industry, and formed the higher production efficiency through its slow drawing speed and faster formation of equal characteristics. Nowadays, the multi-link mechanism of mechanical pressure has gradually replaced the traditional mechanical technology, thus gradually becoming one of the important development directions of the machinery manufacturing industry in our country.

Fig. 2. Development of multi-link for mechanical presses

Compared with the traditional principle of mechanical manufacturing, multi-link mechanical pressure applied in our country has made great improvement and progress, through the analysis and generalization of the relevant data, and the main advantages of this are the performance level, the design cost, the drawing speed, the depth of drawing, the drawing and the mold productivity. The results are shown in Table 2. Through the analysis of its main characteristics, the theory of the technology can be further improved and provide a theoretical basis for the better application of it in practical production and life [14]. From the analysis results, it can be seen that for the mechanical press, the multi-linkage mechanism has a great improvement in comparison with the traditional press. The introduction of this kind of pressure mechanism can further provide some technical support for the development and development of the related machinery and equipment in the development industry, so that the mechanical manufacturing can effectively reduce the waste of related materials which may be caused in the related product manufacturing process, and further improve the efficiency and speed of the machinery manufacturing, effectively increase the quality and production of the products, and further apply the products for later products, provide some technical support and scientific basis for the application of late-related products, which in theory proves that the new mechanical manufacturing technology can meet the application and development of other industries [15].

Then, through the analysis of the shortage of mechanical pressure multi-link technology in China, the general results were obtained, as shown in Fig. 3.

In this study, the mechanical horse products designed by an industry in China were analyzed and taken as examples. The relevant information was read and summarized, and the friction between its components was ignored without considering the weight of the various parts of the mechanical horse itself. The maximum displacement of the relevant parts in a certain direction was taken as the function target, the

parameters of the whole mechanical parts were analyzed, and the structural parameters of each component were further optimized. The optimization results of each parameter are shown in Table 3. Through the simulation of the relevant parameters of the mechanical horse products, then all the bars were simulated and calculated. In the case of the Loc_Y value, the value of Loc_Y was taken as the maximum value of –198 mm and the minimum value of –215 mm.

Table 2. Analysis of the advantages of multi-link mechanism of mechanical presses

Analysis level	Traditional presses	Multi-link presses
Structural level	The contact speed of the sliding block is fast, the possibility of tearing material is increased, the noise and vibration are larger, and the heat inside the mould is stronger, and the die life is short.	The contact speed of the sliding block is slow, the possibility of tearing the material is reduced, the noise and vibration are reduced, and the heat inside the die is reduced, and the service life of the die is prolonged.
Design cost	Higher.	Due to the change of the drive part, the other parts are still standard designs, and the motion curve can be modified according to the requirements of the work piece, thus reducing the cost.
Deep drawing speed	Deep drawing speed is relatively high and uneven; the space velocity is relatively slow, the production efficiency is low.	The drawing speed is relatively low and uniform; the space velocity is faster and the production efficiency is higher.
Drawing depth	70 mm	320 mm
	The crank radius and the crank torque are larger, so that the press structure is relatively loose, the overall size increases, and the weight of the machine is increased.	Crank radius and crank torque is small, so that the press structure is compact, the overall size is reduced, thus reducing the weight of the machine.
Drawing forming	Relatively low strength steel	High strength steel
Mold productivity	Relatively low	Higher

Then, based on the optimization value, the parametric analysis of the optimization point and coordinate direction of all the indexes of the mechanical horse product was further carried out, and the sensitivity of all the parameters was analyzed. The results are shown in Table 4. As can be seen from the results that through the analysis of the sensitivity, the values of DV_10, DV_11 and DV_12 were large, which indicated that these three indexes had great influence on the design of me-

chanical horses. Therefore, in the design of the mechanical horse products, these three indicators need to be more attention to effectively improve the quality of the product.

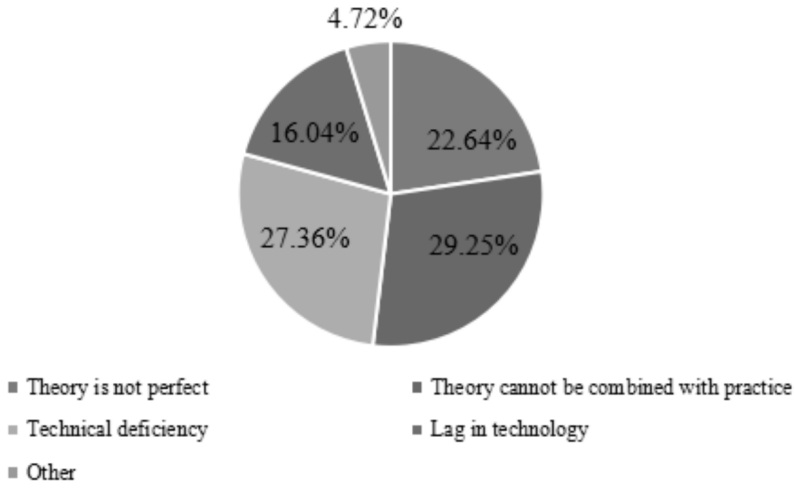

Fig. 3. The shortage and defect of multi-link technology of mechanical press in our country

Table 3. Analysis of the advantages of multi-link mechanism of mechanical presses

	Loc_X	Loc_Y	Loc_Z
POINT_B	(DV_1)	(DV_2)	200.0
POINT_C	(DV_3)	(DV_4)	200.0
POINT_D	(DV_5)	(DV_6)	200.0
POINT_E	(DV_7)	(DV_8)	200.0
POINT_F	(DV_9)	(DV_10)	200.0
POINT_H	(DV_11)	(DV_12)	200.0

Through the analysis of the sensitivity, the relevant important indexes were determined, and the indexes were optimized. The optimization results are shown in Table 5 and Fig. 4. Through optimization, it is found that the relevant indicators have better stability, and other related characteristics have also been greatly developed and improved.

5. Conclusion

With the development of the world economy, many technologies have been developed and improved to a great extent. Under the trend of this world, China's economy and various industries have developed and improved to a great extent.

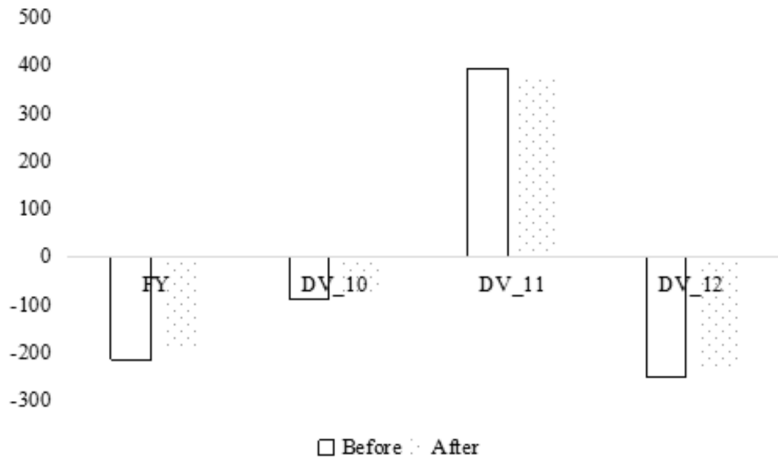

Fig. 4. A comparative analysis of the results of the optimization of the indicators

The development of these industries also provides a certain impetus and positive impact for the promotion of China's overall economic strength. Especially as an important pillar industry in China, the development of machinery design industry is of great significance to the promotion of China's comprehensive strength.

In today's era, as a new mechanical design method, the multi-link mechanism of mechanical press provides more important influence for the development of machinery industry. However, the relative theories and techniques of this kind of technology in our country are still relatively weak.

Table 4. Maximum displacement sensitivity of the optimum design variables of the D point at the end of the leg mechanism in the Y direction

Design variable	Optimization point	Coordinate direction	FY sensitivity
DV_1	POINT_B	X	1.0
DV_2	POINT_B	Y	1.0
DV_3	POINT_C	X	–1.2
DV_4	POINT_C	Y	–1.1
DV_5	POINT_D	X	–0.5
DV_6	POINT_D	Y	0.6
DV_7	POINT_E	X	0.6
DV_8	POINT_E	Y	–0.2
DV_9	POINT_F	X	0.8
DV_10	POINT_F	Y	–3.5
DV_11	POINT_H	X	–3.9
DV_12	POINT_H	Y	–3.6

Table 5. Comparative analysis of each indicator optimization

	FY	DV_10	DV_11	DV_12
Before optimization	–215	–89.7	393	–253
After optimization	–189	–85.3	374	–228

In view of this deficiency, the related concepts of multi-link mechanism of mechanical press were summarized. The multi-link presses were analyzed and compared with traditional presses, and their advantages were found. Mechanical horse was taken as an example, the related results were analyzed, the sensitivity of all of its indicators was analyzed and the main indicators were optimized based on the sensitivity. The results proved that the optimized index is more stable. The research aims to provide some theoretical basis and scientific support for the development of China's machinery construction industry. Because the technology has a wide range of application, the research is only on one side are discussed, and research has certain limitation, but still can be used as a reference for related research.

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