Teaching Reform and Practice of the Curriculum of Mechanism Design Based on Innovation Ability Training

Liang-Wen WANG\textsuperscript{1,a,*}, Feng ZHAO\textsuperscript{1,b}, Wen-Liao DU\textsuperscript{1,c}, Guo-Fu LUO\textsuperscript{1,d}, Fan-Nian MENG\textsuperscript{1,e}, Hong-Wei LI\textsuperscript{1,f}

\textsuperscript{1}School of Mechanical and Electrical Engineering, Zhengzhou University of Light Industry, Zhengzhou, 450002, China

\textsuperscript{a}w_liangwen@sina.com, \textsuperscript{b}zfnlglg@tju.edu.cn, \textsuperscript{c}dwenliao@zzuli.ecu.cn, \textsuperscript{d}luoguofu@zzuli.ecu.cn, \textsuperscript{e}mengfannian123@163.com, \textsuperscript{f}76169079@qq.com

*Corresponding author

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Abstract. We proceed to teaching reform practice in the course of mechanism design. The course is prepared for the undergraduates. The aim of the reform is to lead students to apply the studied knowledge, and to cultivate the innovation ability and innovation spirit for the students. This work includes textbook research, integration of curriculum content, supplementary materials of updated content, guiding students to read scientific papers, and designing of comprehensive experiment, all of which are based on the innovation ability training for the reform work of the mechanism design. In the aspect of intensifying knowledge application ability and cultivating innovation ability, the reform has developed the situations of the positive interaction between teachers and students. By this way, teaching and studying can be developed adequately.

Reform Necessity of the Course of Mechanism Design

Now, mechanical product design capability is reflected in comprehensive national strength and competitiveness for every country. The soul of the manufacturing is design, and the soul of the manufacturing and machinery is Mechanism. Thus manufacturing is based on the theoretical research of modern mechanisms. The excellent mechanical structures are the bases of the modern equipment and the products with market competitiveness. It is important for the undergraduate students majored in mechanical engineering to cultivate their abilities of initiatively acquiring and applying knowledge and the ability of the independent thinking. The students should master the basic theory of modern mechanism design to strengthen the mechanism innovation design ability\cite{1}.

The course of mechanism design is arranged in the major of mechanical engineering. Under the limit of teaching time and complex theories, the content reform of the course is the first problem to be solved. With the rapid development of the modern mechanism design theory and the teaching research methods, the reform direction of teaching work is that the classical theories and the modern design methods of mechanical structure should be connected well, guiding students to solve the scientific problems by using the extended theories.

With the rapid development of computer technique, the field of mechanism design has experienced a great revolution. It simplifies the process of product design along with the application of the CAD/CAM/CAE techniques. This change improves the innovation ability and competition ability of the companies and realizes the great transformation of the design methods of the mechanical products. It is necessary to reform the course of mechanism design based on the cultivation of CAE technique of the students.
Teaching Innovation Measure of Mechanism Design Based on Innovative Capacity-Building

Teaching Content Integration of the Course

In Zhengzhou University of light industry, the major of the mechanical design and automation includes three training courses of the light industry machinery design, manufacture and control to cultivate the knowledge of students. In the direction of machinery design skills, the courses are set by using modern mechanism innovation design, automatic mechanical design skills and modern design method.

On the main line to develop the innovative ability of institutions course, it is key point in the content integration and reform of the mechanical principle, the mechanism design and the design methodology. In addition, it is necessary to integrate the duplicate content and the cross section. Optimizing the content and dealing with the relation between foundation and improvement are also necessary.

The mechanism design is the continuation and improvement of the content of the mechanical principle. Thus the integration of the teaching content between mechanism design and mechanical principle is the key point.

The course of mechanical principle mainly takes into account the thought introduction of the work principle and design for the common mechanical structures. The graphical method is the main method in design, however, the popular design method is the analytical method combined with the graphical method. For the course of mechanism, the main method is analytical method. When the courses of mechanism design and mechanical principle are arranged for the same major, it is results that the teaching content is repeated and the teaching time is wasted. In addition, the basic concepts are easily confused due to different textbooks for discussing the same thing. Thus, it is necessary to integrate the teaching contents between mechanical principle and mechanism design.

The popular textbooks of mechanical principle and mechanism design are that one is the mechanical principle compiled by prof YS Shen[2]and the other is the mechanism design compiled by prof WQ Cao and Prof ZY Xu[3]. Thus, it is taken as an example to discuss the content integration.

1) Motion design of planar linkage

The literature [3] uses many sections to introduce the design contents of the planar linkage, which includes the integrated analytic method and approximate synthesis problems of the planar linkage. Thus the contents of the literature [3] cover that of the literature [2]. When the course of mechanical principle is given in class, the part of analytic method for the planar linkage design can be less taught.

2) Design of cam mechanism

The cam mechanism is widely used in automatic mechanical design. The literature [3] uses many sections to introduce the cam mechanism design, the contents of which are very broad. The literature [2] gives the repeated contents compared with literature[3]. Therefore, when teaching the course of mechanical principle, the graphical method is mainly taught in literature [2], the analytical method is simply introduced.

3) Design of the planetary gear train

The literature [2] mainly introduces the basic concepts and the simple design of gear train. The deep theories and the design of complex gear train for the design of planetary gear train are appeared in the literature [3]. Thus the contents of the tow literatures can be taught separately.

4) Design of the combined mechanism

The literature [2] separately introduces the combination, type and function, and the design of the combined mechanism. The literature [3] introduces the combination, kinematic analysis, and the comprehensive analysis of size of the combined mechanism. The course of mechanical principle should mainly arrange the contents of the combination, type and function. The teaching contents of the design of the combined mechanism should be arranged in the course of mechanism design.
Through the integration of the above content, the teaching time of the class can be condensed. The time can be used for the experimental teaching. This way encourages students to do practical application according to the mechanism knowledge.

Research of Relevant Textbook

The course of mechanism design is plentiful. It is an essential subject with theory and practice. It is impossible to obtain the result that the students of engineering colleges can master all of the knowledge of mechanism design in short studying time. Thus, combined with the training objectives, it is necessary to select some suitable contents. Compared with the contents and characteristics of the similar textbook, we can obtain the advanced level of teaching and studying.

Following textbooks possess obvious characteristics.

(1) The literature [4] is deeply taught in the kinematic chain research and the transformation theory of mechanism.

(2) The literature [5] proposed the general method and basic laws for mechanism analysis. It can optimize parameters of mechanism by using the platforms of VB and VC.

Combined the textbooks research and our research direction, the teaching contents are focused on the linkage design and CAM mechanism. The literature [3] is our basic textbook, which is combined with the literature [4].

Combination of Teaching Material Contents and Scientific Research

Mechanical and Electrical Engineering of Zhengzhou University of Light Industry has studied the robot technology that is the main direction. The research object contains:

(1) Theory of bionic robot and industrial robots: Bionic robot is the research object. We research the robot configuration, kinematics solver, dynamic modeling, image guiding, multi-information fusion and decision analysis, error analysis and motion compensation, and independently developed bionic robot. In the study of industrial robots, articulated robot is object, the characteristics of which are modular structure, the error distribution, dynamic modeling, parameter calibration, the compensation of control system of basing dynamics.

(2) The application and research of typical industry robots: Dedicated welding robot is researched and developed for tower crane. The research of welding robot includes theoretical modeling, kinematics and dynamics analysis, simulating and experimental study. We research and develop practical welding robot.

Robots are used in light industry, packaging industry, loading and unloading. The unloading industrial robot is the research object, the research of which includes the hardware layer, the control layer and software layer.

The content of the curriculum needs to be linked with the teachers' scientific research work. It is necessary that students need participate in the scientific research work of the teachers, which can complete the requirements of thesis research. Thus, we publish the "Fundamentals of robotic mechanisms" internal textbook. This textbook describes kinematics and dynamics theory for robot mechanism.

Curriculum Content Should Be Combined with the Excellent Journals

In the course of study, we emphasize that the students should read magazine related with curriculum content. Students are required to read a related magazine paper after course. International journals: Mechanism and Machine Theory, IEEE Transactions on Robotics, IEEE Journal of Robotics and Automation and so on. Domestic journals: Chinese Journal of Mechanical Engineering, Journal of Mechanical Engineering, Mechanical Design, Mechanical Science and Technology magazine articles. In teaching, we arrange four hours to explain and guide learning, and make students track the subject development. For the classic articles, students should have to learn and discuss.
Experiments of Design and Comprehensive for the Cultivation of Innovative Ability

We have arranged laboratory exploration. General principles of the open experiments are:

Comprehensive experimental principle is that the experiments should focus on the comprehensive experiment. Generally, the students propose design program, which should generally involve multiple knowledge through experiments to achieve comprehensive application of knowledge.

Principle of innovation is that requires students to design experiments, it must be able to design their own experiments in innovation.

The principle of combining research activities of teachers is that the students are actively encouraged to participate in research projects of teachers, combine with requirements of the subject, dig up comprehensive and innovative experiment.

In the open experiments, student can make a comprehensive application about knowledge of relevant institutions. It can integrate knowledge of many courses, such as mechanical principles, mechanism design, computer programming, computer control, robotics technique. The design of different types of experiments can cultivate students' innovative awareness and ability, as well as ability of comprehensive application knowledge and practical problems-solving.

Examples of Comprehensive Experiment Design

It is necessary that require students to integrate application of computer programming, three-dimensional design software, and digital modeling and driving of certain institution. For complex mechanism, study calculation and analysis need Matlab software, Kinematics and dynamics simulation and ADAMS software. Tensile and extend mechanism of stamping die is taken as an example:

1. Functional analysis

The tensile and extend slider need a certain force function and a period of constant velocity motion with quick return characteristics. This place has the extrusion greater pressure because of the cam mechanism as a dotted line contact. It is easy to wear or fatigue damage, so the mechanism should not use a cam mechanism, a link mechanism can be employed to achieve force function. The institution also requires the period from constant movement and quick-return characteristics known four mechanism. It cannot be achieved. This institution requires a minimum of six institutions.

2. The type of mechanism comprehensive

Six mechanisms are only two basic structures: Stephenson and Watt chain. The mechanism according to the principle of evolution can be obtained 11 kinds of design. Wherein Stephenson chains can evolve in the form of six kinds of mechanism, Watts chain can evolve in the form of five kinds of mechanism. As shown in Fig.1. At experiment, according to the number of classes, divided into 11 groups, each group studied one design.

![Stephens chain evolution mechanism](image1.png)

(a) Stephens chain evolution mechanism  

![Watts chain evolution mechanism](image2.png)

(b) Watts chain evolution mechanism

Figure 1. Stretching and prolonged mechanism of stamping die.
Figure 2. Mathematical model of stretching and prolonged mechanism of stamping die.

Figure 3. 3 Dimensional motion simulation of tensile and extend mechanism of stamping die.

(3) Dimensions of mechanism comprehensive
It will adopt a comprehensive theory of mechanism to do dimensions of mechanism comprehensive. In Stephenson chain evolution mechanism (e) to establish comprehensive mathematical model, shown in Fig.2.

(4) The simulation by three-dimensional modeling software
The 3D modeling software built mechanism motion simulation model and simulation analysis, as shown in Fig.3. Check the movement accuracy of the stroke meets the requirements, such as it is interference or not, etc.

(5) Motion analysis by software
Kinematic analysis by using VB or Matlab software, the mechanism output component relative to the input component angle or displacement of time, velocity and acceleration curve.

Figure 4. The movement analysis curve of tensile and extend mechanism of stamping die.

Conclusion
The effect of teaching reform is obvious. The learning enthusiasm and the ability of experiment studying are all improved. In addition, the innovation of students is enhanced, and the manipulative ability got some exercise.
Modern talent cultivation of innovative ability is a systematic engineering. It is impossible to be finished by integrating or changing the contents of certain course. However, the determined content is that the good arrangement of courses and the optimization of the related courses are helpful for the realization of the final aim.

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