Application of modern simulation technology in a mechanical design course for outstanding engineers

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ABSTRACT: Aimed at improving teaching practice in a mechanical design course, this article expounds the relationship between modern simulation technology in the teaching of a mechanical design course and outstanding engineer training. The teaching quality of basic mechanical courses has an impact on students' innovation ability. Use the modern simulation technology in teaching can quickly set up a gear mechanism model for dynamic analysis. In actual design, it is possible to create a conceptual model, which is, then, converted into an actual model that can clarify the outstanding function of modern simulation technology for the student in innovation practice. It has the advantages of economising the teaching cost, overcoming hardware constrains, model prediction, promoting students' innovation and manipulative ability, and can popularise and develop in a more cost-effective manner in the university.

INTRODUCTION

The main goal of an excellent engineering education and training scheme is for industry, facing the world and facing the future, to cultivate a wide range of engineering technical personnel of high quality who have strong innovative ability and can adapt to the requirements of economic and social development. It has an important guide function for the full range of promoting higher education reform and reasonable optimisation of the talent training structure and quality of college students. Therefore, the cultivation of talent in higher education colleges should pay more attention to the training of senior professionals with strong self-learning ability, innovation consciousness, practice ability, organisation and coordination ability. Starting in 2010 in China, the Ministry of Education's *Excellence Engineering Education Plan*, has led many universities to plan and implement excellence programmes in multiple disciplines.

This study has been prepared in this environment, and built around the characteristics and the idea of the authors' school. Knowledge of the mechanical design course itself is broad, and it is important that the students obtain the capability to produce innovatively designed mechanical products and the ability to solve problems in production practice. This is also the required *Excellence Engineering Education Programme*. So, in the teaching of mechanical design, how to integrate the theory and practice effectively is an important subject that must be addressed. In this article, computer simulation science and technology are used to simulate the process of mechanical design.

Simulation science and technology is the use of computers and special experimental equipment as tools. Taking the experimental model of physical systems as the basis, this involves using mature software and hardware technology to analysis, research and design of existing or non-existing structures, to achieve the goal of analysis and to solve problems [1]. Computer simulation technology is used to analyse and solve problems, including geometric modelling, model analysis, optimisation of control parameters, models and methods of optimisation, and simulation analysis [2]. The virtual prototype technology, on which it is based, has become relatively independent of industrial technology, and it will continue to have a profound impact on the manufacturing industry.

THE CHARACTERISTICS OF AN OUTSTANDING MECHANICAL ENGINEER

The *Outstanding Engineering Education Programme* is a major reform project of the Chinese education ministry to implement the *National Long-Term Education Reform and Development Plan (2010-2020)* and *National Long-Term Talent Development Planning Outline (2010-2020)*, and also a significant measure to promote engineering education towards engineering education power for China [3][4]. The connotation of engineering quality is rich and the characteristics of excellent engineers also diversified. Generally, it includes extensive knowledge and solid professional skills, a capacity for forward-looking and professionalism for the research object, a strong sense of competition and innovation ability, interpersonal and communication skills, social morality and professional ethics and an appropriate

outlook on life and values. Therefore, the quality characteristics of outstanding engineers are not only reflected in *can do*, but also to comprehensively consider issues, such as *should do*, *do not do* and *worth doing*. The mechanical design course is one of the important basic courses for mechanical engineering and automation, and electrical and mechanical engineering, and widely used in many aspects of social and economic life [5]. Through the course of theory teaching, innovative experiments, course design and innovation learning for practice in enterprises several important outcomes are achieved: comprehensive development of the intelligence of students, cultivating students' abilities for sharp observation, imagination, scientific thinking and problem solving. These would provide the necessary theoretical foundation and integrated application environment to cultivate outstanding engineers of innovation ability able to adapt to the needs of economic and social development [6].

APPLICATION OF SIMULATION TECHNOLOGY IN MECHANICAL DESIGN

Mechanical Design is an important professional basic course in the teaching system of cultivating mechanical talent, which plays an important role in the whole course system [7]. The content of the course not only embodies the comprehensive application of some basic courses, but lays the foundation for the follow-up professional courses related to learning and future work. Mechanical Design is mainly about working ability (mainly carrying capacity) of design theory and methods of general machinery parts, which is the most commonly used in mechanical engineering. From the content of the curriculum framework, every chapter of content is independent, and there is no direct correlation in technological logic. The types, characteristics, engineering experience, and the design principles of this course are too complex, therefore, the content of this course is complex, so that students find it to be difficult [8].

The planetary gear train has been widely applied in fields of aviation, ship and metallurgy. It has many merits, such as its small size, compact structure, high bearing capacity, large power transmission and high efficiency, etc. The NGW planetary gear train, which consists of a sun gear, a planetary gear and a fixed inner gear, has the characteristics of simple structure, small axial dimension, super manufacturability and large transmission ratio through multi-stage series. It has been one of the most widely used pieces of equipment in driving devices, so, the study of the NGW planetary gear is of great significance in prompting the technology of the planetary gear train [9].

Romax Designer is a British company that specialises in product development and simulation of gear transmission system CAE software, used for the design and analysis of gear transmission systems. Romax software development and transmission project consultation has had more than 10 years of experience in the field of transmission. It was released in 1995 by Romax Designer and has become the industry standard tool in the field of gear transmission. It is widely used in automobile gearboxes, wind energy and other fields. Romax Designer covers developments in the establishment of conceptual models, components' strength analysis, reliability prediction on system vibration, noise design content prediction of the whole transmission system and closed-loop solution mechanisms of the gear transmission systems. It provides model analysis and optimisation for a variety of complex gear transmission systems. Figure 1 shows a planetary gear design tool that provides three input parameters in different ways: *...module and number of teeth, ring reference diameter and number of teeth* and *ring reference diameter and module*. Students first choose the input mode, then, the input module, pressure angle, and number of planetary gear, the gear tooth number and tooth width.

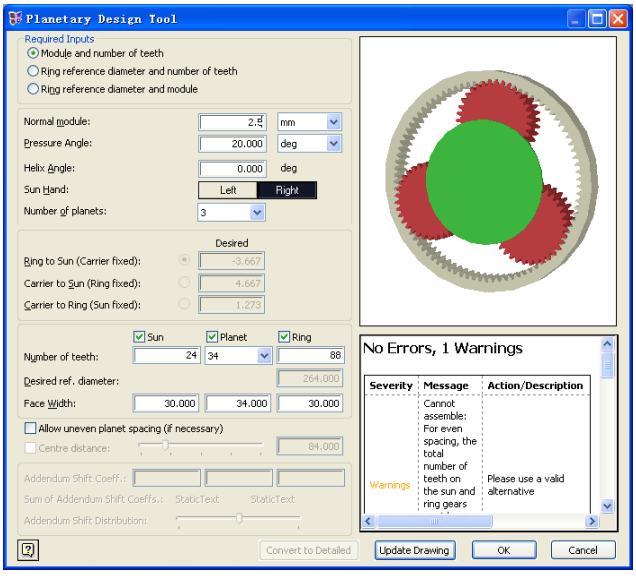

Figure 1: The conceptual model in planetary gear.

The established clutch disc model is only for connect and fixed effects. Because of this, the reducer model of an inner gear ring is fixed; the solution is to establish a concept of the clutch disc, input clutch order and connect with the inner ring gear and, then, set the clutch disc lock. The selected concept clutch options in the component list realise the concept of clutch disc, as shown in Figure 2 and in Figure 3.

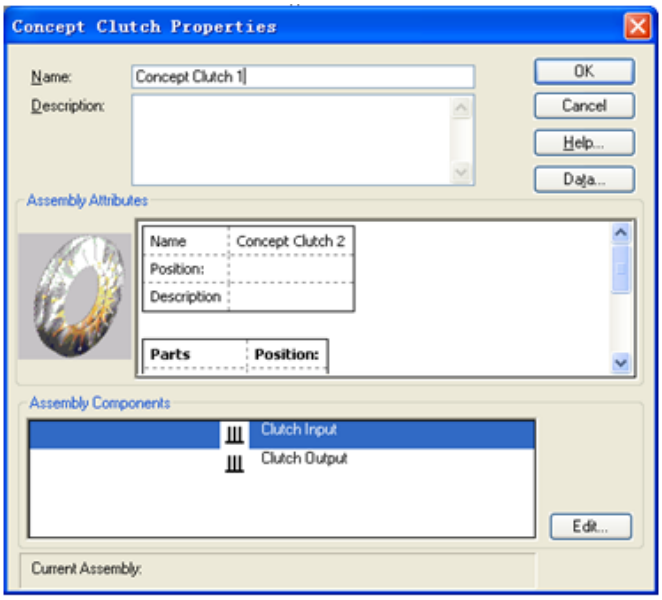

Figure 2: The creation of the concept for clutch disc.

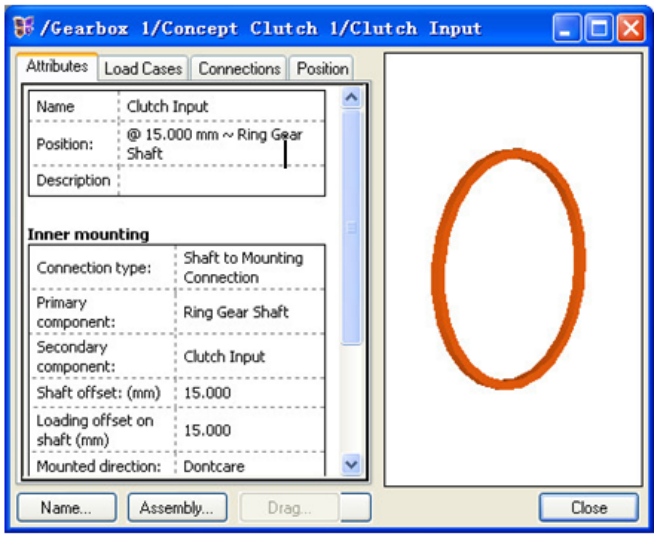

Figure 3: The model of clutch.

The fixed two parts go through Rigid Connection order in Romax (so the model of planetary frame and the output shaft is connected), which play a bolt or a key role. In this model, the output shaft and the planet frame constitute this kind of connection. The Rigid Connection is finished in the creation process of shaft. After the shaft, gear and other components of the model have been established, connections for these parts can be defined. The sun gear and the input shaft connection is established and, then, connected to the planet carrier and an output shaft, the connecting definition of internal ring gear comes last.

The modelling of each part and the constraint relationship have been completed between them, using three-dimensional form for all members to assemble and define position relations of each axis. The location of axis in the gear box was positioning shaft in the gear box and is defined by the coordinate that corresponds to the origin coordinate. Coordinates can be used as cylindrical polar coordinates or Cartesian coordinate system, and the Cartesian coordinates are used in this article. The mutual position of axle must be pre-calculated to ensure that the gear meshing can be normal. The final definition of power transmission system load, input speed of 640r/min and power 11.4 KW, as shown in Figure 4.

When in the definition of power load, the life of the gear reducer can be set, the design life of 10 years (300 working days a year, three shifts), which means 72,000 hours. Finally, run the Romax Designer command dialog to finish test diagnosis model, check the gear meshing relationship for correctness, whether there is interference meshing, gear and shaft integrated installation, etc. If the model fails the test, according to the reasons of failure, make the relevant changes to the model to create the correct model that passes the test.

The model presented in this article successfully passed the test. Upon completion of the conceptual model of the transmission system, it was concluded that the model can only be used for transmission, because the conceptual gear

cannot provide enough parameter for strength checking. In order to conduct the strength check for the gear, the concept model of the gear should be transformed into the specific gear model. According to different model parameters, the material, quality grade, backlash of gear pair and surface roughness parameters of the gear, this model will be set up. The parameters of the model will be described in detail in the following section. The conceptual model of the planetary gear is shown in Figure 5, which has been transformed into a planetary gear model shown in Figure 6. The detailed parameters of the interface are shown in Figure 7 and the rigid model is shown in Figure 8.

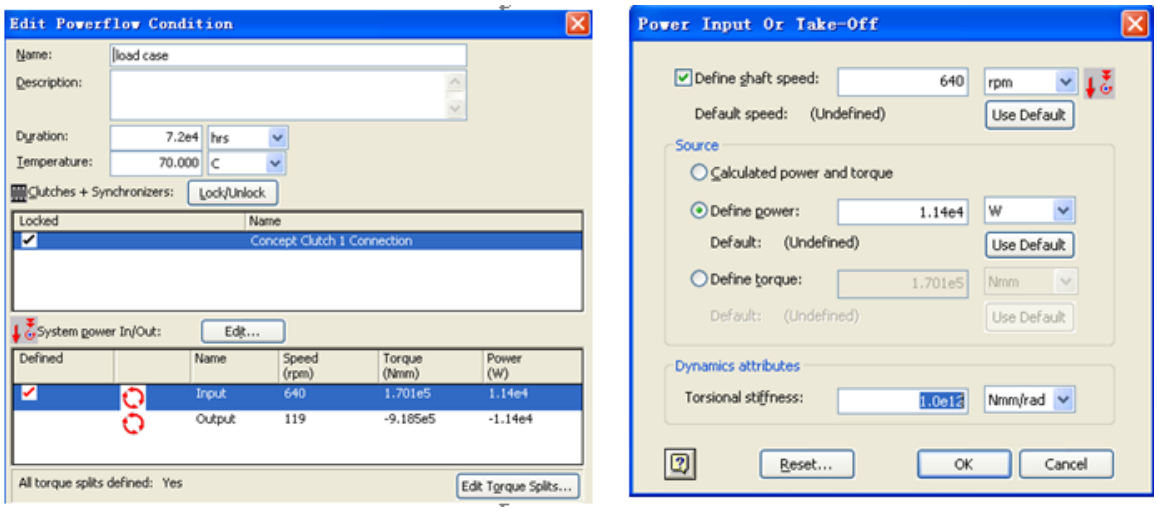

Figure 4: The definition of dynamic load.

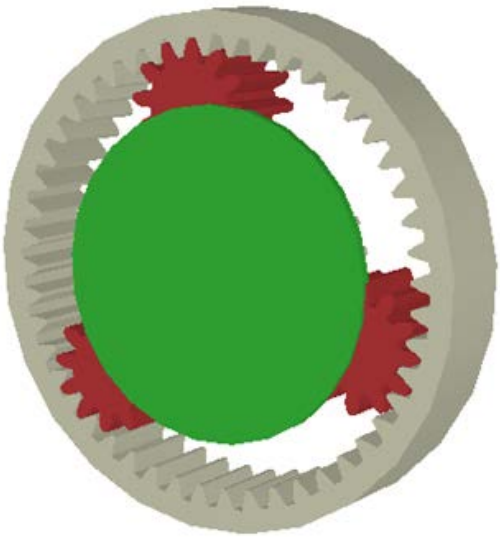

Figure 5: The conceptual model of the planetary gear.

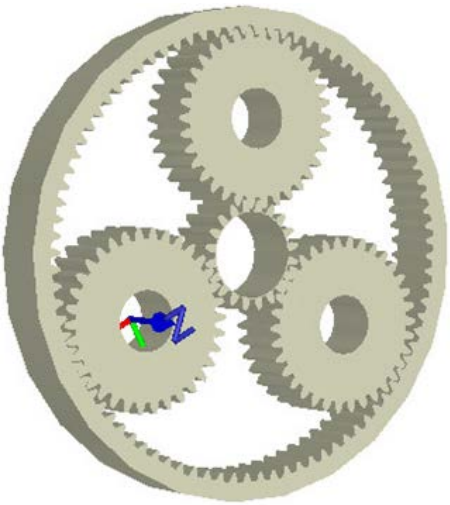

Figure 6: The detailed model of planetary gear.

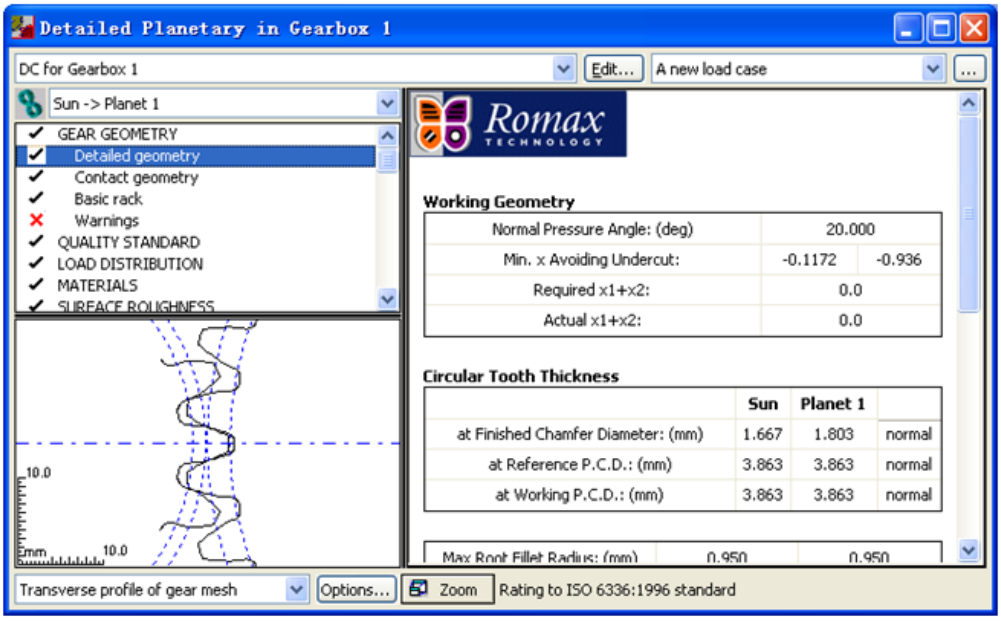

Figure 7: The detailed design process of the gear.

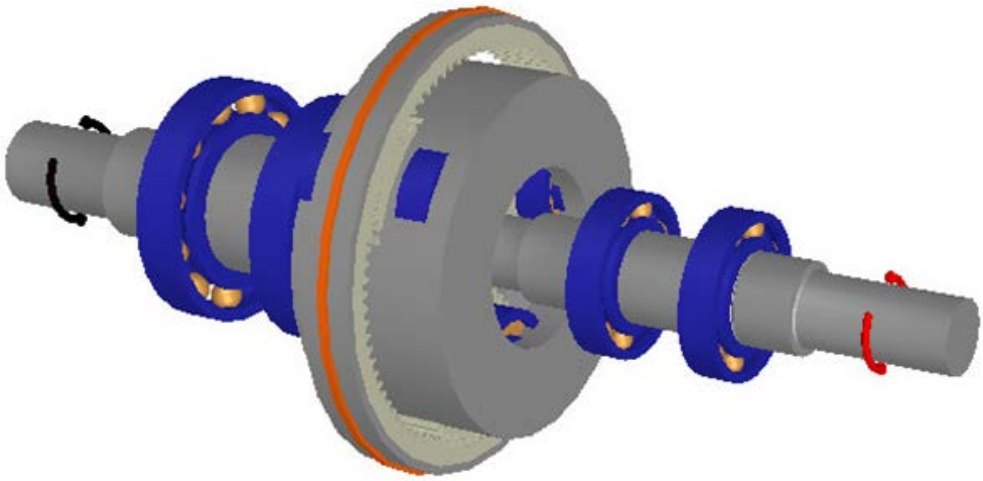

Figure 8: The system of rigid model.

The multi body dynamics model of reduction of rigid flexible hybrid system is shown in Figure 9.

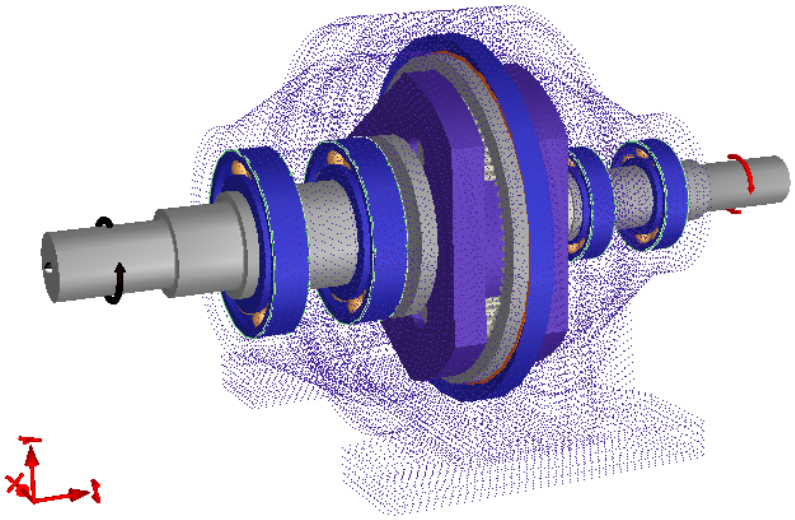

Figure 9: The virtual prototype model of NGW31 planetary gear reducer.

TEACHING EFFECT

Using Romax Designer enables students to have a more vivid understanding of the mechanical design process and have a more profound understanding of mechanical structures commonly used in practice. It also puts forward the idea of a mechanical system to complete the design goals, strengthen the students' proficiency in the use of various kinds of machine tools, enhance the students' ability to discover and process problems, strengthen coordination and teamwork.

The mechanical design course teaching practice of outstanding engineering education uses modern simulation technology to build a planetary gear mechanism and its dynamics simulation analysis. It transfers the gear concept model into the concrete gear model to analyse gear parameters, and it shows the general process of mechanical design, strengthens the students' ability to quickly understand mechanical design principles and use simulation techniques to analyse and solve problems. Further, it allows students to fully participate in the product conception, design and implementation processes.

The practice sections inspire students' interest in mechanical design, gradually improve their comprehensive ability and enable them to integrate into society successfully, which is conductive to cultivating high-quality, with the potential for sustainable development of innovative talent.

In recent years, traditional teaching and practice have continued to be reformed, and the training of outstanding mechanical engineers has seen some remarkable achievements and won the provincial excellent teaching achievement award. Meanwhile, the course was named as a provincial quality course for guiding students in the national college of advanced mapping techniques. Also, at a skills contest and a mechanical innovation design competition, numerous awards were won as were at other events. Mechanics graduates from the college are welcomed by enterprises, and the employment rate has reached 99% with higher than average salaries. These are potent confirmations of the excellence of the Mechanical Design Engineer Teaching Programme.

CONCLUSION

In the excellent engineering education training plan, modern simulation technology is used in teaching that can quickly set up a gear mechanism model for dynamic analysis. In actual design, one can create a conceptual model and, then, convert it to an actual model, which means shortening the design time. Presentations directly in the classroom allow students to see the real-time simulation results and increase their awareness, so that they can quickly understand the theory of mechanics and also learn to use simulation to analyse a problem.

The results presented in this article show that the teaching method, including modern simulation technology, were beneficial to students' learning in the mechanical design course, stimulated students' learning desire, and cultivated their ability to solve practical problems at the same time. This strengthened students' learning of the mechanical design concept and mechanical design methods.

ACKNOWLEDGMENT

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