

# Application of Solidworks in Mechanical Design and Drafting Courses

Pei Shixin<sup>a</sup>, Cui fenping and Chu Fuxun

School of Physics & Optoelectronic Engineering, Nanjing University of Information Science & Technology, Jiang Su, Nanjing, 210044

<sup>a</sup>email: peishixin@nuist.edu.cn

**Keywords:** Mechanical design; Mechanical drawing; Solidworks; Classroom teaching

**Abstract.** Solidworks can draw vivid 3D model, it can dynamically show the cut process and can get virtual assembly and assembly exploded view. It start from the perspective of the classroom, examples discussed the ability of solidworks to establish basic volume model, dynamic display the difficult issues in the course of mechanical design and drafting, such as plane intersects with the basic volume model, assembly and exploded view. It is also investigated the role of solidworks enrich the teaching content, improve students' ability of spatial imagination and design skills, stimulate students' interest in learning, enhance the ability of student drawings and identify drawings. It is demonstrated that the using of solidworks for classroom can effectively reduce teaching and learning difficulty, enhance students' interest in learning and helps to achieve good teaching results.

## Introduction

Mechanical design and drafting courses are basic courses for engineering majors. According to different major, emphases of mechanical design and drawing courses are different. However, the main purpose is to cultivate spatial imagination ability, to guide students' solid modeling and 3D construction and to cultivate engineering and technical personnel for the enterprises, who possess modern design philosophy and creative thinking ability. The course, with a strong theoretical and practical quality [1], is aimed at developing students' ability to think, analyze and raise questions about engineering as well as improving the capacity to draw and read engineering chartings through theoretical study and practical experience. Students can benefit a lot from courses like machine design and charting, their spatial imagination ability improved, their groundwork for further professional curriculum study and future career practice well done.

Generally, students are schedules to learn mechanical design and drawing course when they are freshmen. These courses serve as a connecting link between the preceding and the following in cultivating students' professional ability. The teaching quality concerns the grasp of subsequent professional knowledge directly and even influences students' curriculum design and diploma project. Moreover, mechanical design and drafting courses also have a strong application in future career. These courses mainly base on orthographic principles and adopt 2D *figures* to express 3D *objects*. Students need to have a strong spatial analysis capacities and imagination abilities, and it is difficult to learn these courses are short of mechanical parts understanding and adequate space imagination.

The very reason why these courses are difficult to students is that they are required to transfer between 3D *objects* and 2D *pictures* in traditional machine design and charting courses [2]. It would benefit a lot if there is a bridge to combine the design and manufacture process perfectly; take 3D software into mechanical design courses for teaching. Using computer directly for solid modeling can establish a visual link and get rid of the conversion between the 2D *figures* and 3D *objects*. Thus, it will enhance students' understanding about figures and inspire the enthusiasm of students.

## The introduction of Solidworks and its basic function

Solidworks is 3D windows-based CAD software, which adopts parametric modeling techniques, possesses part modeling, assembly modeling and automatic generation of 2D engineering drawings and other functions [3]. What's more, it not only has strong modeling capabilities, but also high part

modeling efficiency. It can also create any complex shapes entity easily. It is one of the 3D software that can achieve the same purpose; however, its operation and interface are the easiest for beginners to master [4]. In addition, solidworks has a strong intelligent assembly function. People can just use mouse to emulate manual assembly without clicking any command. The 3D model is completely related with engineering drawing and assembly model. When the model is modified then the corresponding engineering drawing and assembly model would automatically alter. Accordingly, the designer can also amend on the engineering drawing or assembly model then the modification reflects on the model as well. Besides, using feature manager can display characteristic structure of the model. The feature manager not only can display the order of creating characteristics but also can make it easy for users accessible to relevant information of all characteristics.

In America, lots of famous universities, including MIT and Stanford University, take solidworks as a compulsory course. While Some domestic universities also set up solidworks, including Huazhong University of Science and Technology, Tsinghua University, Beijing University of Aeronautics and Astronautics, Harbin Institute of Technology, Beijing Institute of Technology, Dalian University of Technology, Wuhan University of Technology and so on[5].

Solidworks adopts the ideal of creating 3D parametric part models by designing steps of parts. It not only can plot 3D model easily, but also can provide correct model for further facilitating subsequent modifications, adjustments and assemblies. Moreover, it can adjust irrational structure accordingly and can also make parameter-driven preparation for numerical control processing.

### The application of Solidworks in teaching mechanical design and drafting courses

**The application of Solidworks in substituting traditional teaching model.** Having good spatial imagination is the key to learn mechanical design and drafting courses well. Only the mind has the *objects* to be designed, can we accurately draw the corresponding “pictures” and flexibly switch between the 3D *objects* and the 2D *pictures*. And having a good spatial imagination needs to trainee a large number of solid models. In the traditional instructional model, the solution to make students familiar with solid models is bringing a wooden or plastic physical model to develop students’ spatial imagination. But the method of bringing physical models has obvious disadvantages, for example, in order to allow students see it clearly, the size of the model needs to be as big as possible. However, it’s not convenient to carry large models. Moreover, the models could not be freely modified. Therefore, the traditional models could not satisfy the teaching requirements of mechanical design and drafting courses.

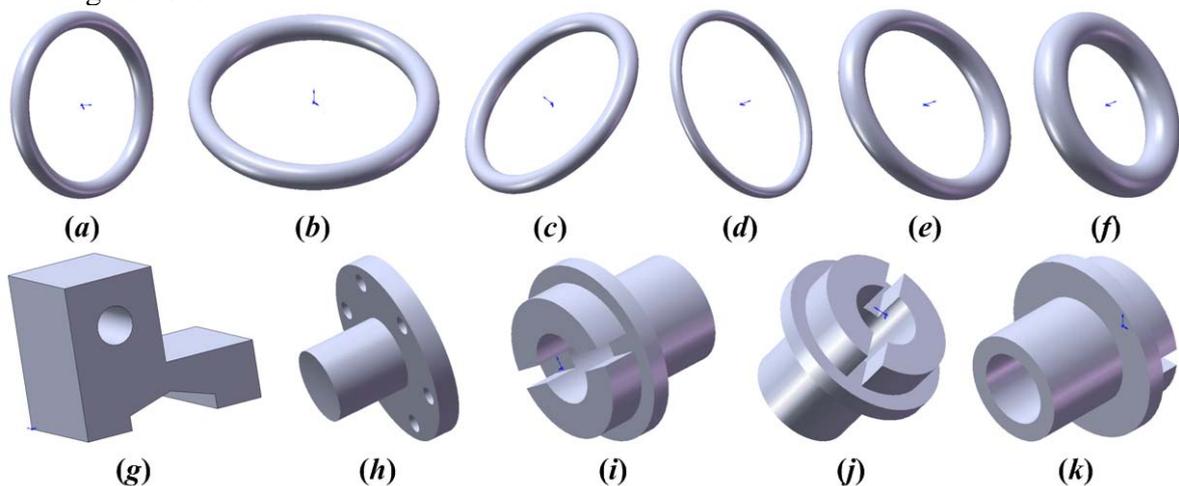


Figure 1 Establish teaching model use solidworks

Applying convenient modeling function of solidworks, it can establish corresponding 3D model and revise it freely, it will give students an intuitive impression of part design. For example, O-ring is a common part in sealing system; however, many students have no idea about this. It’s difficult to describe clearly without corresponding model. As illustrated in figure 1(a) ~ (c), it can easily

establish 3D O-ring model and show the 3D O-ring from different angles by rotating and dragging with solidworks. Despite of observing spatial structure of the same O-ring from all directions, solidworks can also easily modify parameters and show 3D O-ring with different parameters as illustrated in figure 1(d) ~ (f), it will let students establish a visual impression for O-ring. According to the needs of classroom teaching, as is shown in figure 1(g) ~ (h), solidworks can design any 3D model entity conveniently. As figure 1(i) ~ (k) shows, observing 3D entities from different perspectives, these can strengthen students' intuitive impression of parts and increase students' learning interests.

**Application of solidworks in the teaching of intersection of plane and basic stereoscopic.**

Intersection between plane and basic solid is an emphasis and difficulty in mechanical design and drafting courses, which is mainly embodied in lines of section and intersecting lines teaching [6].

Intersection line is formed of two or more than two basic solid by different ways. For example, in two mutually perpendicular surfaces of a rectangular, open two orthogonal cylindrical bore, cylindrical bore intersects the surface of the two, Namely the existence of intersecting line, which is the most basic mechanical drawing course intersecting line, but to understand this basic intersecting lines, also requires extensive spatial imagination. The result of this problem, as figure 2 (a) shows, if with the aid of Solidworks, Only need to draw the two orthogonal cylindrical holes in a rectangular 3D model diagram, intersecting line will automatically generate. By the Drag rotation function of Solidworks, students easily observed intersecting line; figure 2 (b) shows, if we set a transparent entity in Solidworks, adjust spatial direction of the view, and the Intersecting line can be displayed as a whole, which greatly enhances the intuitive intersecting lines. As the Solid is divided into Plano-Stereoscopic and body of curved surface, so Two stereo intersection can be divided into three cases Plano-Stereoscopic and Plane stereo intersection, Dimensional and 3D planar surfaces intersect, 2D surfaces intersect, The corresponding intersecting lines were closed space plotline consists of several sections of the plane curve or line space enclosed space curves and closed curves, In traditional teaching, students are required to possess a strong spatial imagination to understand the intersection lines. The difficulty can be imagined. As is shown in figure 2 (c) ~ (e), it can be very convenient to display intersection lines in various circumstances with the aid of Solidworks.

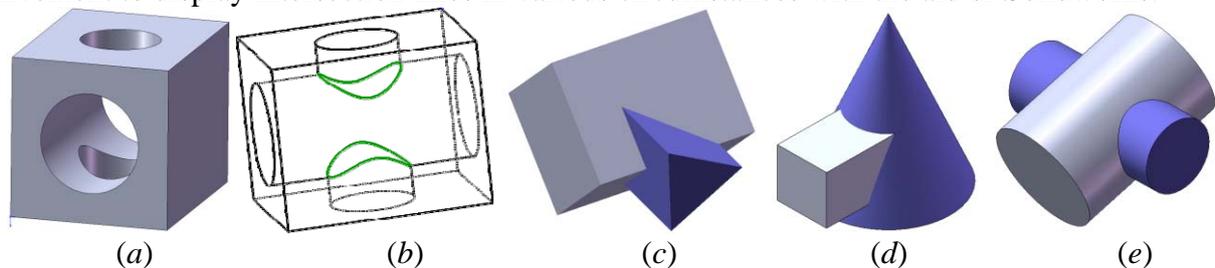


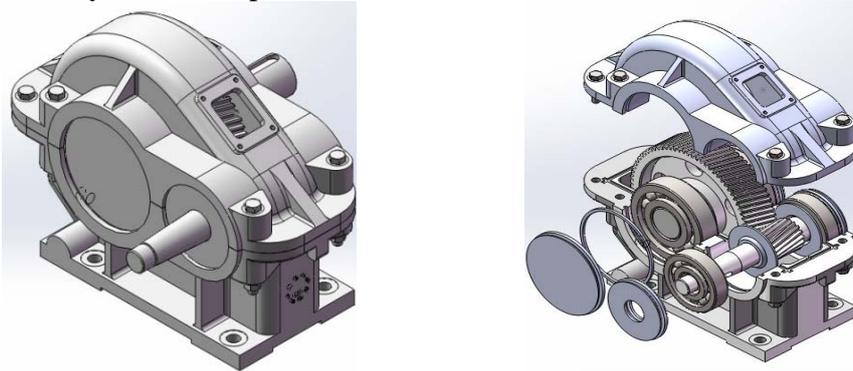
Figure 2 Spatial configuration of displaying intersection lines with Solidworks

**Application of Solidworks in the teaching of assembly.**

The teaching of the assembly is the final but most important part in mechanical design and drafting courses. This part of the content is comprehensive that requires students to connect interpret blueprints with drawing closely, and to have a full understanding to parts of works and main shape, the role of components in the assembly of the whole, the relationship between the parts, Installation and removal of parts order and so on. It is difficult to understand the parts assembly relationship and assembly process because of the lack of perceptual machinery parts for beginners, so in this part of the learning is particularly difficult.

Solidworks can directly simulate the assembly of the parts, and students can have an intuitive understanding of working principle of the assembly, the relative positions of the parts and assembly relationship and the structure of parts and assembly. Figure 3(a) shows gear box assembly diagram using Solidworks. To further deepen the students' impressions about assembly structure, Solidworks also has the function of making an exploded view of the assembly that can be isolated from various parts of the assembly, and show the assembly process of all parts. Figure 3(b) shows the gear box assembly exploded view. Each parts set along the path to complete the simulation animation within a

specific period of time. Students can observe the positions of the parts and relationship between the parts and their assembly relationship.



(a) Assembly of Gearbox      (b) Exploded view of the Gearbox assembly  
Figure 3 Gearbox assemblies drawing with Solidworks

In addition, in the virtual assembly, inspection of parts makes it clear that modeling the assembly of the various parts, errors that occur during assembly. Virtual assembly process and the production process are highly consistent in Solidworks, and it intuitively reflects the true product assembly process that helps students understand the demolition painting parts diagram.

### Summary

Solidworks has many applications for mechanical design and drafting courses. Practice has proven that Solidworks can make the abstract and static theory become image and dynamic teaching demonstration that students can observe the internal structure of the solid model and build process entity. This approach makes the teaching content more visually, and helps students develops spatial imagination and configuration design capabilities. On the basis of arousing students' interest in learning, the *teaching, learning and doing* integration, can effectively reduce the difficulty of teaching and learning, enrich teaching models and classroom content, and stimulate students' enthusiasm for learning. The students gradually form a 3D way of thinking when their passive learning becomes active learning, and enhance the ability to use computer aided design. To learn the basic concept of engineering design helps students quickly establish awareness of modern engineering and develop basic engineering quality, and lay a solid foundation for work after graduation.

### Acknowledgements

This work was financially supported by the foundation of teaching reform research project (2013004, 2013009 and 2014009), School of Physics & Optoelectronic Engineering, Nanjing University of Information Science & Technology.

### References

- [1] Yang Huiying, in: *Mechanical Drawing: Machinery and near Machinery* (Tsinghua University Press, Beijing, 2011).
- [2] Li Huifang, in: *China Educational Technology & Equipment*, Vol. 21 (2011), p. 30.
- [3] Solidworks: A-3D CAD environment, Information on <http://www.Solidworks.com>.
- [4] Wei Zheng, Zhao Gong, Song Xiaoming, in: *Solidworks Design and Application Guide* (Tsinghua University Press, Beijing, 2009).
- [5] Information on <http://baike.baidu.com/view/31530.htm>.
- [6] Tao Hua, in: *Information & Communications*, Vol. 4 (2011), p. 13.