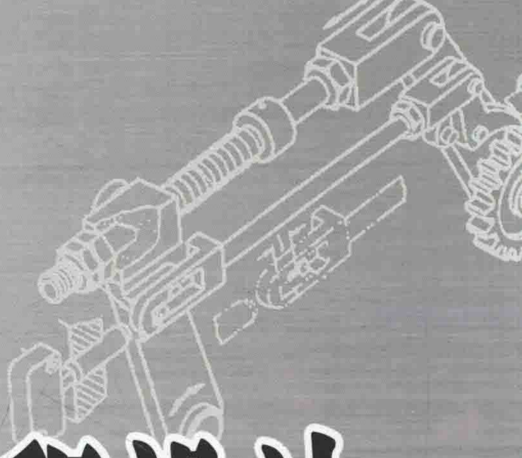
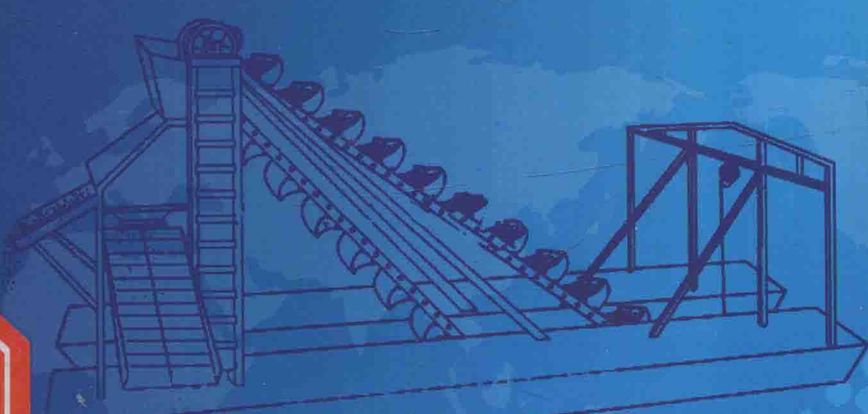


机械设计课程设计

COURSE DESIGN FOR MACHINERY DESIGN

（英文版）

何 波 主编



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【内容简介】 本书内容共分为两个部分。第一部分为机械设计课程设计指导，以常见的二级圆柱齿轮减速器为例，系统介绍机械传动装置的设计内容、步骤和方法。第二部分为机械设计课程设计常用标准和规范，列出机械设计课程设计的常用标准、规范和设计资料，并提供一些参考图例。

本书可作为高等院校机械类专业机械设计课程双语教学或全英文授课的教材或教学参考书。

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前　言

机械设计是机械类专业的一门重要技术基础课，课程设计是该课程必要的实践环节。《机械设计课程设计》（英文版）是根据高等工科院校机械类专业机械设计课程双语和全英文教学的需求，结合沈阳航空航天大学及兄弟院校在机械设计课程设计双语和全英文教学方面的经验编写而成的，与《机械设计》配套使用。

全书共分为两个部分。第一部分为机械设计课程设计指导，以常见的二级圆柱齿轮减速器为例，系统介绍机械传动装置的设计内容、步骤和方法。第二部分为机械设计课程设计常用标准和规范，列出机械设计课程设计的常用标准、规范和设计资料，并提供一些参考图例。全书共20章。第一部分分为8章：概述、传动装置的总体设计、传动零件的设计计算、减速器的构造、减速器装配草图设计、零件工作图设计、装配工作图设计、设计计算说明书编写。第二部分分为12章：机械制图、常用资料和标准、螺纹连接、键和销连接、滚动轴承、联轴器、润滑与密封、减速器附件、圆柱齿轮结构、公差配合和表面粗糙度、电动机以及参考图例和设计实例。

在本书编写过程中，得到了东北大学巩云鹏教授的指导和支持，在此谨致谢意！

衷心希望广大读者对书中不妥之处提出宝贵意见。

何　波

2017年1月

Preface

Machinery Design is an important technological basic course in mechanical engineering education and the course design is an essential practice. This English textbook *Course Design for Machinery Design* is written for Chinese and international students majoring in mechanical engineering or in other related field to meet the basic requirements for this course in advanced engineering universities and colleges. And teaching experiences of Shenyang Aerospace University and other universities in the Course Design for Machinery Design have been combined. This textbook should be used together with *Machinery Design* and many Chinese textbooks have been referred to during the compilation.

There are two parts in this textbook: instruction of course design for machinery design and design information and data. In the first part, the design contents, procedure and method for a two-level cylindrical gear reducer have been introduced. In the second part, the commonly used standards, regulations and design data have been illustrated and some examples have been provided. There are 20 chapters in this textbook. The first part includes 8 chapters: overview, outline design of transmission equipments, design calculations for transmission components, construction of reducer, assembly sketch design, component drawing, assembly drawing design, design and calculation description. The second part includes 12 chapters: drawing, commonly used data and general standard, thread fasteners, key and pin, rolling-contact bearing, coupling, lubrication and sealing, associated component, structure of cylindrical gear, limit and fit, tolerance and surface roughness, electromotor, drawing examples and cases.

Professor Gong Yunpeng from Northeastern University has kindly directed the compilation and put forward some insightful suggestions.

Since it is our first attempt to compile a technical textbook in English, there would be some mistakes and inappropriate treatments inevitably in the book. So your suggestions and criticism are welcomed sincerely.

He Bo

2017.1

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PART Ⅰ INSTRUCTION OF COURSE DESIGN FOR MACHINERY DESIGN

PART Ⅰ　INSTRUCTION OF COURSE DESIGN FOR MACHINERY DESIGN

Chapter 1 Overview

1.1 Purposes of Machinery Design Course Design

"Machinery design course design" is one of the important practice steps in machinery design. The course design has significant meanings:

(1) To enhance students' ability to link machinery design theory with practice.

(2) To learn the general approach to machinery design.

(3) To make a training of the basic skills on machinery design, including: calculation, drawing, and usage of the design data, manuals, standards and specifications.

(4) To have a correct design thought. Not only the innovation opinion, but also the existent experience is very important.

Besides, machinery design course design also establishes the foundation for specialized course design and graduation design.

1.2 Contents of Machinery Design Course Design

In machinery design course design, the mechanical transmission device of a general machinery is usually selected as the design subject. As shown in Fig. 1 - 1, the transmission system includes gear, worm gear, belt, chain, coupling and other parts, and general knowledge of the mechanical design is involved. Reducer design is suitable for the students' knowledge level, and can help students to get a basic comprehensive training.

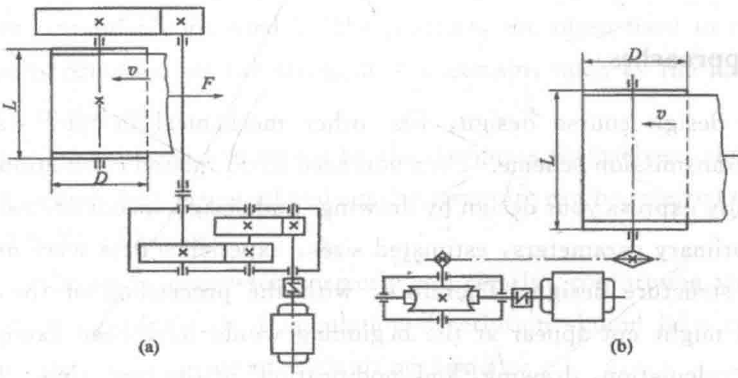


Fig. 1 - 1 Types of design titles

The contents of the course design include:

(1)Determining the transmission scheme;

(2)Choosing motor, calculating the total transmission ratio and distributing the ratios at all levels, calculating the motion and kinetic parameters;

(3)Designing the transmission parts;

(4)Designing shafts, selecting and checking key joints;

(5)Designing bearing combinations;

(6)Designing housing and accessories;

(7)Designing lubrication and sealing systems;

(8)Designing and drawing assembly drawing and component drawings;

(9)Writing the design and calculation description.

1.3 Procedure and Schedule of Machinery Design Course Design

(1)Preparation: to understand the design task, requirements, working conditions and contents;

(2) Outline design of the transmission equipment: to select the type of motor, to calculate the kinetic and dynamic parameters of the transmission equipment;

(3)Design calculation for transmission components;

(4)Assembly sketch design;

(5)Working drawing design of components and assembly;

(6)Description writing for design and calculation.

1.4 Approaches to Machinery Design Course Design and Notes

1.4.1 Approaches

Mechanical design course design, like other mechanical design, starts from the analysis of the transmission scheme. Then you need to do related calculation and structure design, and finally express your design by drawings and design specifications. In the design process, some primary parameters, estimated sizes, experience data were used during the calculation and structure design. Therefore, with the proceeding of the design, some problems which might not appear at the beginning would have been exposed gradually, which requires "calculation, drawing, and modification" at the same time.

Any attempt to determine all the sizes and structures of the parts only by the method of theoretical calculation without sketch drawing, or the reluctance to make necessary changes once the sketch is drawn makes it incorrect.

1.4.2 Notes

(1) It is necessary to do design work seriously, carefully, and neatly. Any slight mistake in calculation or structure design may lead to product scrap.

(2) To make your design reasonable, practical, economical and of good manufacturability, comprehensive thinking and combining theory with practice are important.

(3) It is necessary to correctly realize the relationship between inheritance and innovation, and use standards and specifications properly. Correct usage of the standard specification is not only favorable to the interchangeability and manufacturability of parts, which leads to good economic benefits, but also it can reduce the workload and accelerate the design. Generally, national standard and the department specification should be strictly followed. However, standards and specifications are not made to limit innovation and development. Therefore, when standards and specifications have contradictions with the design requirements, you should design them by yourself.

(4) It is necessary to deal well with relations between calculation and structure design, and make overall decision after taking all factors into consideration.

1) Sizes calculated through the formula derived from geometric relationship are very strict. Generally, they cannot be rounded off or changed. For example, the center distance of gear transmission $a=\frac{m(z_1+z_2)}{2}$. If a is rounded off, z_1, z_2 or m should be changed correspondingly, in order to keep identity relation.

2) Formula derived from the strength, stiffness and wear conditions are usually in inequality relationship. For example, according to the strength calculation, diameter of a shaft is at least 32 mm, but the size used finally may be 50 mm, considering the structure, installation, disassembly, processing and manufacturing requirements of other parts that the shaft fits with (such as coupling, gear and rolling bearing, etc.).

3) Empirical formulas concluded by the practice, are often used to determine sizes, when the shape is complex, or the strength is uncertain, such as the housing. And the sizes are often rounded off.

4) Secondary sizes can be determined by the designers themselves, the processing and using conditions should be considered and similar structure can be referred to, such as fixed bushing and oil baffle plate, etc.

(5) Drawing should be expressed correctly and clearly, conforming with the standard of mechanical drawing; design and calculation description should be accurate and neat, conforming with the requirements of the writing format.

Chapter 2 Outline Design of Transmission Equipments

The tasks of the transmission's outline design include: determining the transmission scheme, selecting the type of motor, distributing transmission ratio reasonably and calculating the kinetic and dynamic parameters of the transmission equipment. It can prepare conditions for the design and calculation of all levels of the transmission parts.

2.1 Determination of Transmission Scheme

Reasonable transmission scheme should meet the performance requirements of the working part and work reliably. It should also have the advantage of simple structure, compact size, easy processing, low cost, high efficiency and convenience in operation and maintenance etc. But it is very difficult to meet all the requirements at the same time. So we should balance them and ensure the key requirements.

When multi-stage transmission is used, we should reasonably select transmission parts and determine the transmission order of them, to gain a reasonable scheme. The following points should often be considered.

(1)Belt drive is a kind of friction drives. Its transmission is steady and it can absorb quite a large amount of sudden shock. But its transmission ratio is neither constant nor exact. And while transmitting the same torque, the structure size of the belt drive is bigger than that of other form of transmission. So belt drives should be placed as high-speed transmission. While transmitting the same power, if the rotation speed is higher, the torque would be smaller.

(2)The operation of chain drive depends on the meshing of chain and sprockets, and its average transmission ratio can keep constant. Moreover, chain drive can operate under an adverse working environment. But the instantaneous velocity of the chain is not constant, leading to impacts. So, generally, chain drives are used at low-speed levels instead of high-speed ones.

(3) The open gearing should be arranged at low-speed levels because of its poor working condition, bad lubrication and severe wear.

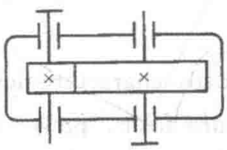
(4) Usually, helical gear is used in multi-stage gear drive, because its stability is better than spur gear.

2.2 Types of Reducer

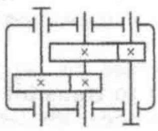
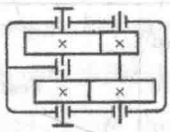
The reducer is usually used as an individual unit to transmit power between motor and working part. Reducers have some features, such as compact structure, high transmission efficiency, reliable drive and convenient maintenance, which makes them extensively employed in various machines.

In order to accommodate different purposes for all kinds of mechanical transmission, reducers have many styles, whose features and applications are shown in Table 2 - 1.

Table 2 - 1 Features and applications of reducers

Name	Kinematic diagram	Recommended range of speed ratio	Features and applications
Single cylindrical gear reducer		$i \leqslant 10$	There are spur gears, helical gears and herringbone gears. Spur gears are applied in the transmission whose speed is low or workload is small. For higher speed and heavier transmission load, helical gears or herringbone gears should be adopted. Most housings are made of cast iron, and sometimes welded structure or casting steel is used. Rolling-contact bearings are normally employed, and only under heavy load or specially high speed transmission, sliding bearings are used. Other types are similar to the above

Continued

Name	Kinematic diagram		Recommended range of speed ratio	Features and applications
Two cylindrical gear reducer	Expanded type		$i=8-60$	The structure of expanded type is simple, but gear's position relating to the bearing is not symmetric, so the shaft should possess greater stiffness. In order to decrease the nonuniformity of load distribution along the gear width, high-speed stage gear should be located far away from the input of the torque. It is recommended that this type is adapted to stable load. Helical gears can be applied to high-speed stage or low-speed stage, but spur gears are better to be utilized in low one
	Coaxial type		$i=8-60$	The length of this reducer is short. The immersion depths into oil are approximately equal for the two pairs of the gears. But the axial size and weight are larger, and the carrying capacity of high-speed gears cannot make full use; Load is not uniform along the gear width, for the middle shaft is too long and the stiffness is decreased. There is only one shaft end for input and output, which limits the flexibility of layout

2.3 Selection of Motor

According to magnitude and properties of workload, characteristics of working parts and working conditions, the category, type, structure form, power and speed for the motor can be selected, so the model of motor will be determined.

2.3.1 Category, Type and Structure Form of Motor

The category, type and structure forms can be selected based on power type (DC or AC), working conditions (environment, temperature and position), magnitude and properties of workload, starting characteristics, overload situation, etc.

Usually without special requirements, three-phase AC motors are adopted, especially the Y series motors. If the system starts, brakes, inverts frequently, such as hoisting equipment, the motor is required to have small rotational inertia and large overload capacity, so three-phase asynchronous motor for metallurgy and hoisting could be chosen, such as YZ series (squirrel-cage) or YZR series (wound-rotor). The technical data and outline dimensions of motors are shown in Table 19-1 and Table 19 - 2.

2.3.2 Power of Motor

The operation and economy for motor are both affected by the power selection. Too low power can't sustain the normal work of the machine, leading to the motor failures in advance due to overload. And too high power can also bring many drawbacks, such as high price, inability to fully play, and lower efficiency and power factor, and waste will be made.

For the machine whose workload is stable (or changes very little) and operation is continuous for a long time (as conveyer), the motor can be selected according to the rated power, and the verifying of heat and starting torque of the motor is not required. The following should be insured:

$$P_0 \geqslant P_r \tag{2-1}$$

where P_0— rated power of motor (kW);

P_r— required power of working part (kW).

P_r can be calculated as below:

$$P_r = \frac{P_W}{\eta} = \frac{Fv}{1,000\eta} \tag{2-2}$$

where P_W— required effective power of working part (kW);

η — total efficiency from motor to working part;

F— peripheral force of working part(N);

v — linear velocity of working part(m/s).

For different special machine, the calculation of P_W is different. For example, belt conveyor:

$$P_W = \frac{Fv}{1,000} = \frac{F\pi nD}{60\times 10^6} \tag{2-3}$$

where D —diameter of driving roller of belt conveyor (mm);

n —speed of driving shaft of working part (r/min).

The total efficiency η is determined by the composition of transmission equipments as follows:

$$\eta = \eta_1 \eta_2 \eta_3 \cdots \eta_W$$

where η_1, η_2, η_3, ..., η_W are the efficiencies of kinematic pairs or transmission pairs (such as coupling, gear, belt, bearing and roller).