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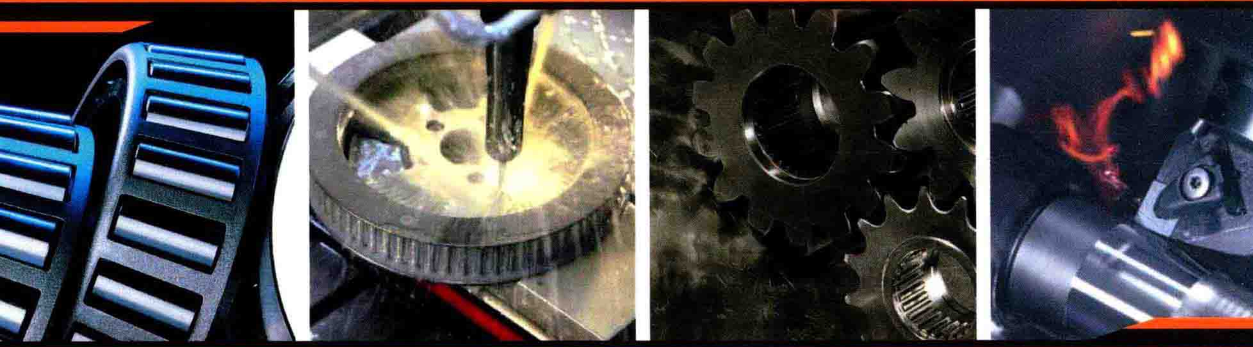

Mechanical Manufacturing Process

机械制造工艺学

刘书暖　编著
By Shunuan Liu

西北工業大學出版社

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【内容简介】 本书介绍了与现代制造工业发展相适应的机械制造工艺，共四章内容。主要内容包括机械加工工艺规程编制、加工精度、表面质量、机床夹具设计等。本书叙述简明，概念清楚，内容丰富，注重理论与实践的接合，突出实用性，适用于机械制造专业的教学，同时也可作为机械类其他相关专业用书，以及从事机械设计制造的工程技术人员的参考书。

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Preface

Manufacturing is ubiquitous in life. From daily use pen, cups, tables and chairs to the automobile, aircraft and the mystery spacecraft and space exploration, all cannot do without manufacturing. How are these products made out? How is the cup made from the mud? What is the mud experience?

This book starts from the mechanical product manufacturing; explains what the machining process is, how to plan the process and what should be considered in the planning. The main contents are the process planning, machining accuracy, surface integrity, and the design of the fixture in machine tool. It is fit to be the textbook of the mechanical engineering major in the university.

For students whose major is mechanical design or mechanical manufacturing, to make products designed by theirselves be manufactured under certain production conditions, in the most economical method in the premise of the quality, according to a predetermined productivity requirement, the structures on the design drawings should have good technological efficiency and be beneficial to being manufactured, used, repaired. So a good designer should have some knowledge about mechanical manufacturing process.

This course is a practical course. The content of textbooks must be adapted to the students' practical basis. The engineering practice has proved that students can not learn this course well if they can not understand the basic processing methods or only strengthen the study of the theoretical content of the course. Taking the practicality of this course and the wide range of knowledge involved into account, teachers can arrange some spot teaching, such as a variety structure of typical fixture, machining process of typical parts, special process and so on. This will not only enhance students' perceptual knowledge, but be also conducive to classroom teaching.

Due to the limited level of editor, the book will inevitably have many defects and mistakes. I adjure readers to provide criticism and correction.

This editor would like to acknowledge the support from publish funding of Northwestern Polytechanical Univeristy and the editors of the book named Mechanical Manufacturing process and published in Chinese, Changsheng Jing, XiuDe Ma etc., who had worked in Northwestern Polytechnical University.

2015.9

Contents

Chapter 1 Machining Process Planning

1.1 Basic Concepts

1.1.1 PRODUCTION PROCESS (PP)

Production Process (PP) is the whole process in which raw materials are transformed into a final product. It includes the transportation and storage of raw materials, production preparation process, the manufacturing process and the process of becoming part of the blank, the assembly of the components and products, testing, painting and packaging, as shown in Fig. 1-1.

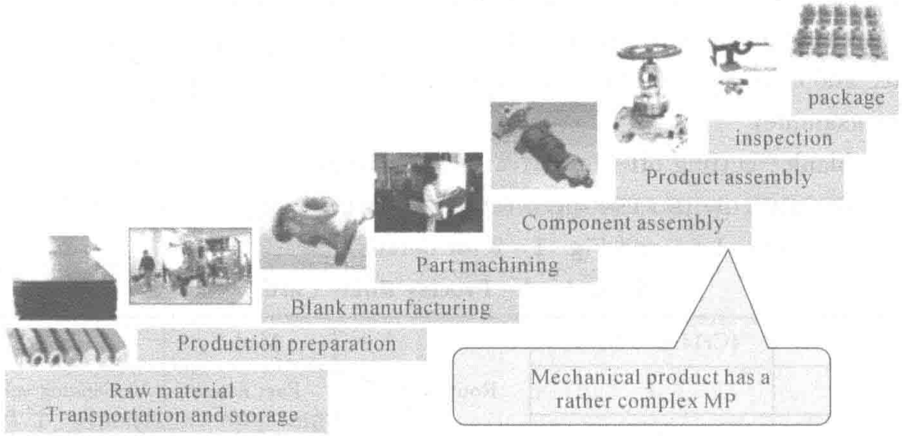

Fig. 1-1 Production Process

By the above process, it can be seen that the production process of mechanical products is quite complex. To facilitate the production and improve labor productivity and reduce the production cost of the products, the production of a product, often be done jointly by many factories, which is conducive to the standardization of parts and components and the organization of specialized production.

The production process of a factory can be divided into production processes of a number of workshops according to the workshop. The raw material (semi-finished products) used in a workshop, may be the finished products in another workshop; the finished products may be the semi-finished products in another workshop. For example, the finished products (castings and forgings) in casting and forging workshops are the "blanks" of the mechanical processing workshop; the finished products of the mechanical processing workshop are also the "raw material" of assembly workshop.

1.1.2 MANUFACTURING PROCESS (MP) AND PROCESS SPECIFICATION

Manufacturing Process (MP) is the process of altering the workpiece's shape, dimension, relative position, physical properties and appearance to obtain a semi-finished or final product in PP.

Manufacturing Process (MP) includes casting, forging, stamping, welding, machining, heat treatment, plating, assembly, etc. Two basic types:

a. Process of making an alteration of a part—alter the part's shape, physical properties and appearance in order to add value to the material.

b. Assembly process—no alteration, joining two or more components.

Process Route is the sequence of products or components which are performed from the blanks to the finished products storage passing enterprise departments or operations. Process Route is the main reference of the formulation of the process and the allocation of manufacturing tasks to the workshops. General can adopt the different process to achieve the final processing request. Technical personnel should determine the technological process according to the workpiece output, production equipment and technology conditions of workers etc. and confirm the technological process in the form of a file according to certain format. For example,

blank—cutting off—heat treatment—turning—grinding—drilling

This file is called the process specification. It is the discipline file strictly enforced by production staff (Table 1-1 and Fig. 1-2 for details).

Table 1-1 Process Route Card

<table>
<tr><td colspan="2">Material</td><td>4Cr14Ni14W2M0</td><td rowspan="3">Routing card</td><td colspan="2">Model</td><td>××××</td></tr>
<tr><td colspan="2">Number</td><td>1</td><td colspan="2">Part name</td><td>Accelerating valve bushing</td></tr>
<tr><td colspan="2">Kind and size of blank</td><td>Bar, $\phi 19\times 1215$</td><td colspan="2">No. of the part</td><td>359—120</td></tr>
<tr><td>No. of operation</td><td>Name of the operation</td><td>Machine tool</td><td>Fixture</td><td>Tool</td><td>Measuring</td><td>Remark</td></tr>
<tr><td>0</td><td>Blank</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>5</td><td>Cutting</td><td>Turret lathe C336-1</td><td></td><td></td><td></td><td></td></tr>
<tr><td>10</td><td>Heat treatment</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>15</td><td>Cut face and drill reaming</td><td>Turret lathe C336-1</td><td></td><td></td><td></td><td></td></tr>
</table>

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<table>
<tr><td>Material</td><td colspan="2">4Cr14Ni14W2M0</td><td colspan="2" rowspan="3">Routing card</td><td>Model</td><td>××××</td></tr>
<tr><td>Number</td><td colspan="2">1</td><td>Part name</td><td>Accelerating valve bushing</td></tr>
<tr><td>Kind and size of blank</td><td colspan="2">Bar, $\phi 19\times 1215$</td><td>No. of the part</td><td>359 — 120</td></tr>
<tr><td>20</td><td>Cut cylindrical</td><td>Lathe C616A</td><td></td><td></td><td></td><td></td></tr>
<tr><td>25</td><td>Grind cylindrical and face</td><td>Grinder M120</td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="7">…………</td></tr>
<tr><td>45</td><td>Drill hinge hole</td><td>Bench drill
Z4006</td><td>Jig
6304/0907</td><td></td><td></td><td></td></tr>
<tr><td colspan="7">…………</td></tr>
<tr><td rowspan="2">Book the change of this file</td><td></td><td>planner</td><td></td><td>Examiner</td><td colspan="2"></td></tr>
<tr><td></td><td>Proof reader</td><td></td><td>Approver</td><td colspan="2"></td></tr>
</table>

The traditional method of formulation of the process specification is confirmed by technical personnel according to their own knowledge and experience and relevant technical data. Along with the electronic computer technology widely entering into the mechanical manufacturing field, at present, more and more people study and adopt the computer aided process specification technology domestic and overseas. It makes the tedious, backward formulation of process specification realize optimization, systematization and modernization. It is a new method which is worthy of our further research and extension.

The main content of this course is studying a series of problems in the process of machining process.

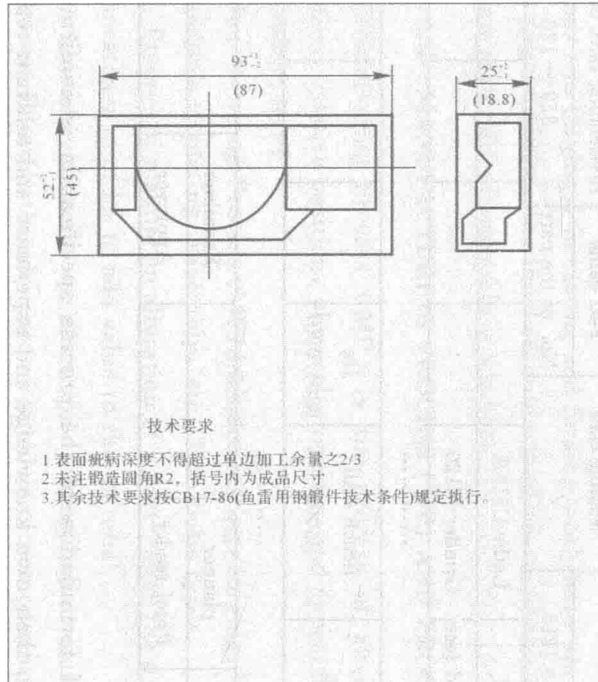
1.1.3 COMPOSITION OF MECHANICAL MANUFACTURING PROCESS

Mechanical Manufacturing Process consists of a sequence of operations. The blank becomes the finished part or final product through these operations in turn. An operation could be divided into steps or strokes.

1.1.3.1 Operation, Step and Stroke

1. Operation

A sequence of operations, through which the blank can become the final product, constitutes the mechanical MP. The part of the process is continuously completed in which one or several workpieces are machined by one or a group of workers in a workplace at the same time. It is the basic unit of process.



工艺规程

设计定型	总号	年	月	日

产品代号	SB211
部、零件代号	00Ⅲ-1300
部、零件名称	舵叉Ⅰ
工艺类别	自由锻造
共　册　第　册	页数

锻造工艺规程卡片

产品代号	零件名称	舵叉Ⅰ	锻造方法	自由锻造	张次	2
SB211	零件代号	00Ⅲ-1300	每台减数	0	张数	

材料		剖面尺寸及长度	胚料重量	每个胚料可锻件数
	名称			
	牌号			
	状态			
每个锻件可制零件数	锻件重量(kg)	零件成品重量(kg)	废料重量(kg)	
1	0.990000			

锻造火次	0
火耗(kg)	0.01
锻造比	

操作注意事项：除按本工艺文件执行外，其余按锻造工艺守则Q/SP102-90)执行。锻造过程始终锻造温度用光学高温计测量。

工序号	工步号	工序或工步内容	设备名称	设备型号规格	工艺设备名称	工艺设备代号	加热规范(℃)始锻	加热规范(℃)终锻	冷却方法	工种
1		检验原材料牌号，尺寸及表面疵病			直尺					检验工
2		加热	反射炉		光学高温计		20	1180		锻工
3		锻造	空气锤	250 kg	工具自备		1180	800	空冷	锻工
4		挂标牌			字头榔头					锻工
5		(标记SB21100Ⅲ-13)								
6		检验			直尺卡钳					检验工
		按图纸尺寸及技术要求进行检验								

文件号	标记	处数	日期	签字	文件号	标记	处数	日期	签字	编制单位	编制		质量会签	
											校对		批准	
											审核			

技术要求

1.表面疵病深度不得超过单边加工余量之2/3
2.未注锻造圆角R2，括号内为成品尺寸
3.其余技术要求按CB17-86(鱼雷用钢锻件技术条件)规定执行。

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设计						所属装配号
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审查						共 4 张 第 4 张
工艺检查						
标准检查						
审定						
校准						

Fig. 1-2　Process Route Card

2. Step

The part of an operation is continuously completed on the following condition: the machining surface, cutting parameters and cutting tool are unchanged. Operation of Hole 2 includes three steps: drilling, boring and boring the circinate groove (Fig. 1-3).

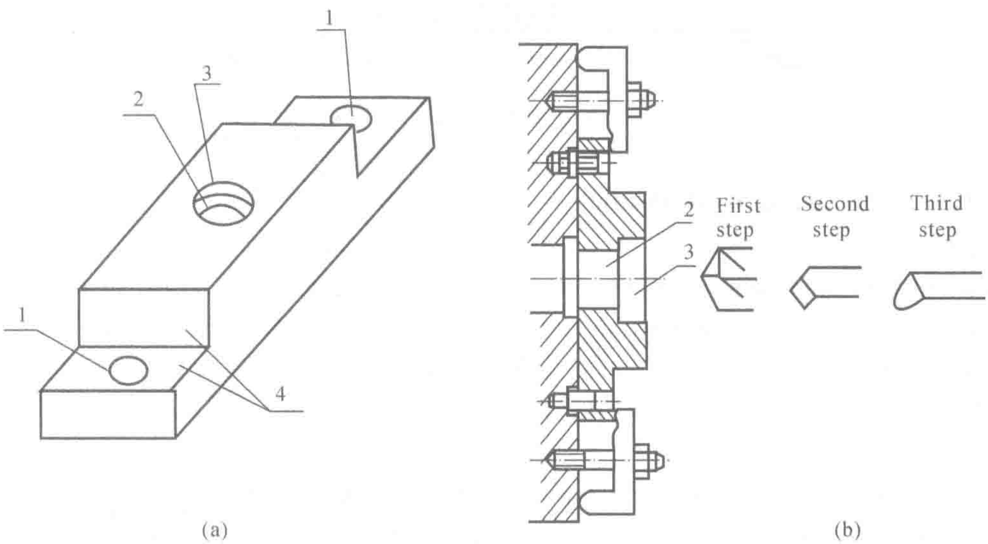

Fig. 1-3 Steps in an operation

The composite step in which the several surfaces are machined by several cutting tools respectively at the same time, is thought as one step, as shown in Fig. 1-4.

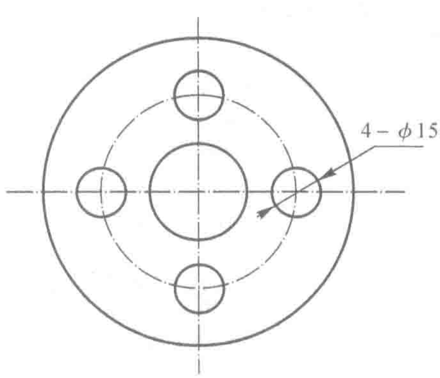

Fig. 1-4 A step includes four steps machining same surfaces

3. Stroke

It's a part of step in which the cutting tool performs a feed motion relative to the workpiece in a feed speed, as shown in Fig. 1-5.

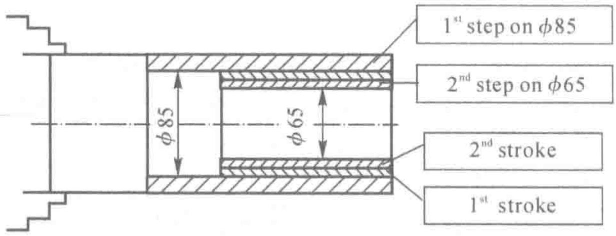

Fig. 1-5 Making stepped shaft by using the rod

1.1.3.2 Setup and Work Position

1. Setup

A part of the operation being completed in one clamping is called setup. In an operation, a workpiece on the machining position could be setup one or several times. But setup times should be reduced as far as possible, for additional setup will increase the error and auxiliary time of loading and unloading the workpiece.

2. Work Position

To perform a certain operation content, after clamping the workpiece one time, the workpiece and the fixture or the movable part of the equipment occupies each position relative to the fixed part of the cutting tool or equipment, as shown in Fig. 1-6.

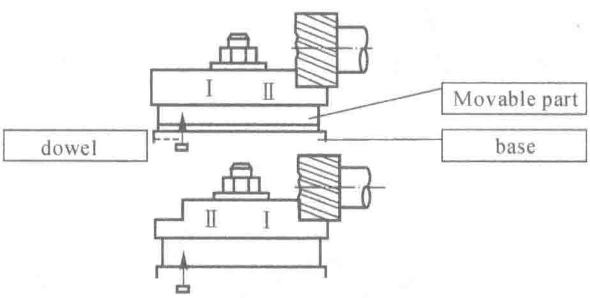

Fig. 1-6 Work position

Finally, we use the machining process of the hexagonal screw to illustrate the concrete application of these common terms, as shown in Fig. 1-7 and Table 1-2.

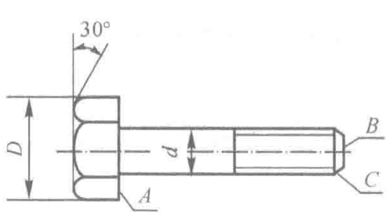

Fig. 1-7 Screw

Table 1 - 2 Mechanical manufacturing process of screw

Op.	Setup	Step	WP	Stroke
Ⅰ	1	(1)Turning end surface *B*	1	1
Turning	3 jaw chuck	(2)Turning cylindrical *D*		1
		(3)Turning full diameter of thread *d*	2	
		(4)Turning end surface *A*		1
		(5)Chamfering *C*		1
		(6)Turning thread		10
		(7)Cutting off		1
Ⅱ	1	(1)Chamfering(30°)	1	1
Turning	3 jaw chuck			
Ⅲ	1	(1)Milling hexagon (composite step)	3	3
Milling	rotary clamp			

1.1.4 RELATION BETWEEN PRODUCTION QUNANTITY AND PROCESS

The annual output of the product or the part including spare and waste ones, usually is calculated as

$$N=Qn(1+a)(1+b)$$

In that,

N—Production qunantity of the part;

Q—Annual output of the product;

n—The number of the part of each product;

a—Spare ratio;

b—Waste ratio.

According to the production quantity, production batch can be divided into three different types: single production, batch production and mass production. With different production types, the detail of process will be different. In single production, the process route generally is only maked; in batch and mass production, process planning should be maked in detail, because if you consider any detail in every operation inappropriately, that can seriously affect the quality of products and the economic effect of production.

Different production types, will also affect specific contents of the process. Because there is a close relationship between the product structure and manufacturing process, the production type, to a certain extent, also affects the regulations of the product design and technical requirements.

1.1.5 WAYS TO OBTAIN THE DIMENSION PRECISION

In the mechanical processing, there are two main ways to obtain the design dimension and the required precision.

1. Trial-cutting

Cut a segment of the machined surface and measure the dimension, then cut and measure it again. Until the requirements of the dimension and precision are met after several times cutting and measuring, the whole surface can be cut.

2. Ways to Obtain Dimension Precision Automatically

a. Use tools with fixed dimension. Because the tool is of fixed dimension, the dimensions of hole or groove can be obtained directly in the error range, for example: drill, reamer and grooving cutter.

b. Set the tool at a fixed distance. Adjust the tool's position relative to the machine tool or the fixture by a stroke stop dog or a stoke control cam. Then a batch of workpiece are machined.

c. Machine by a tool guider. For example, drill bushing and copying device.

d. Guarantee the precision specified by the equipment itself. Stop machining automatically while meeting the required dimension by some devices, for example: automatic measurement or numerical control.

Obtaining the dimension precision automatically is a main way in batch and mass produce and the premise of analyzing the questions on the position datum selection, dimension conversion and machining precision in this course.

1.1.6 TECHNICAL BASIS AND PROCEDURES OF PROCESS PLANNING

The following original materials are bases and conditions to make process planning.

a. Part drawing, assembly drawing and production instructions.

b. Blank drawing and material profile specification.

c. Production site conditions (equips, tools, worker etc.) and other technical specification.

d. Production program.

To make the process planning genenally according to the following steps.

a. Analysis and study Part drawing and assembly drawing, conduct process review and analysis.

b. Determine the dimension of the blank or material profile according to material standard.

c. Draft process route (determine machining methods of every surface, select the locating datum and setup methods of operations, divide process stages and arrange operation order etc.).

d. Determine the process dimensions, technical requirements and test methods.

e. Determine equips, cutting tools, fixtures and auxiliary tools in every operation.

f. Fill in all process files.

1.2 Analyzing Part Drawings

Drawings are the original documents to plan the MP. By drawings, the planner can be familiar with the properties, uses and working conditions of this product, and be clear of the assembly position and the roles of all parts before reviewing the technological efficiency.

The contents of analyzing the part drawing and reviewing the technological efficiency are:

a. Are the technical requirements reasonable on the drawings?

b. Do the drawings lack the necessary dimensions, views or technical requirements?

c. High precision, low roughness or excessive technical requirement will make the process so complex as to be difficult to be machined.

On the different conditions, blank manufacturing, part machining and product assembly can be performed in the economical way. There are some examples about technological efficiency comparison of structures below.

As shown in Fig. 1 - 8, the right one possesses a groove for withdrawing the tool, which can be machined and reduce the cutting tool and grinding roller wear.

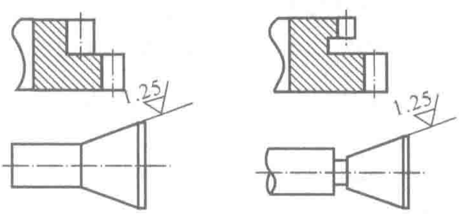

Fig. 1 - 8 Example 1

As shown in Fig. 1 - 9, the right one adopts the same width to decrease the number of tools and the time of changing tools.

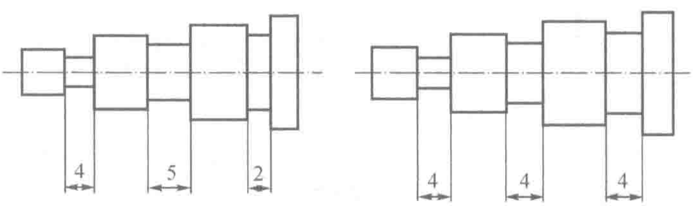

Fig. 1 - 9 Example 2

On the right drawing, two slots locate in the same direction, so they can be machined in one setup to increase the productivity, as shown in Fig. 1 - 10.

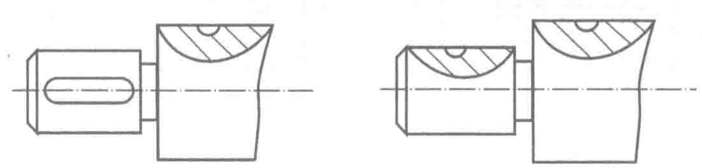

Fig. 1 - 10 Example 3

On the left drawing, it is not easy to draw into the cutter and finish the hole machining, as shown in Fig. 1-11.

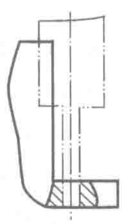

Fig. 1-11 Example 4

The right one can avoid drill lean and break while drilling in or out the slope, as shown in Fig. 1-12.

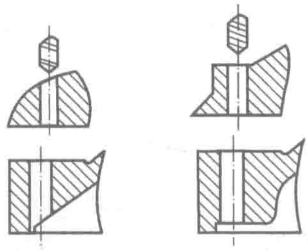

Fig. 1-12 Example 5

The right one can save the material, reduce the weight of the workpiece and avoid drilling deep holes, as shown in Fig. 1-13.

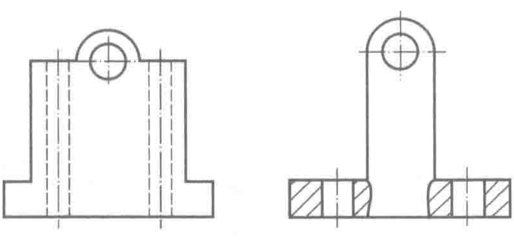

Fig. 1-13 Example 6

The right one can reduce thread processing of the deep hole, as shown in Fig. 1-14.

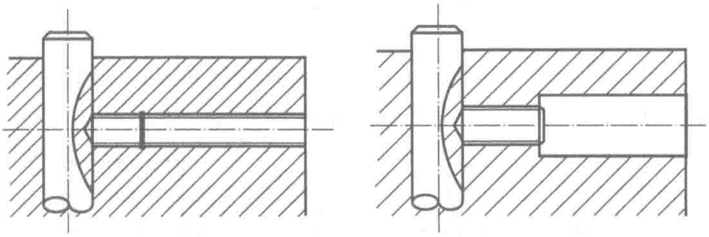

Fig. 1-14 Example 7

The right one can reduce the labor of the bottom processing and decrease the flatness error and increase the contact stiffness, as shown in Fig. 1 - 15.

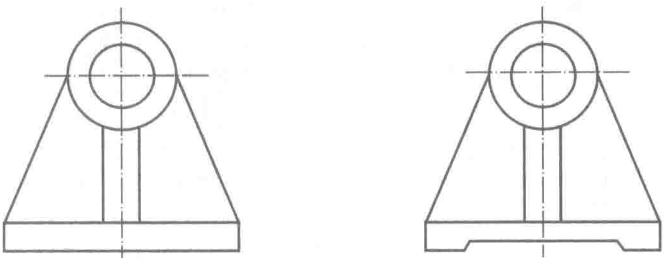

Fig. 1 - 15 Example 8

The right one shortens the length of hole and adopts the bosses as the locating surface at the ends to reduce the cost of machining the hole and ends, as shown in Fig. 1 - 16.

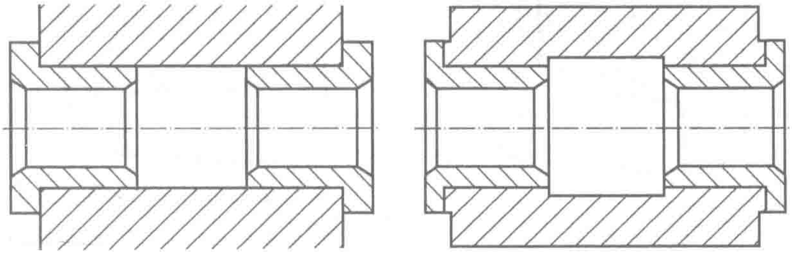

Fig. 1 - 16 Example 9

The boss in the box is too larger than the hole, so it is not easy to be processed. Therefore, the right one is better, as shown in Fig. 1 - 17.

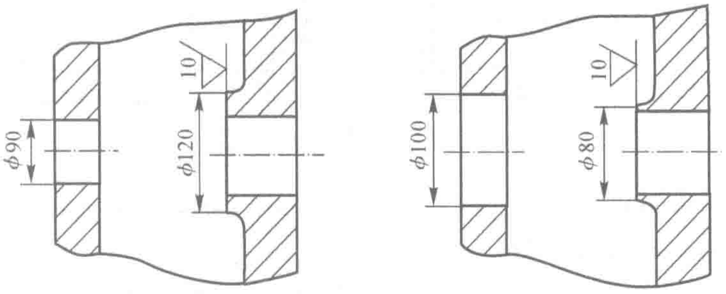

Fig. 1 - 17 Example 10

External surface of the box is easier to be processed than internal surface, so external surface should be selected as the assembly surface instead of internal surface, as shown in Fig. 1 - 18.

It is better for machining and measurement to design a circinate groove on excircle of part 1 instead of on hole of part 2, as shown in Fig. 1 - 19.