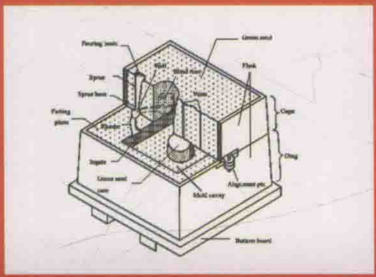
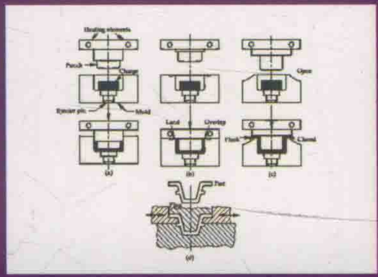
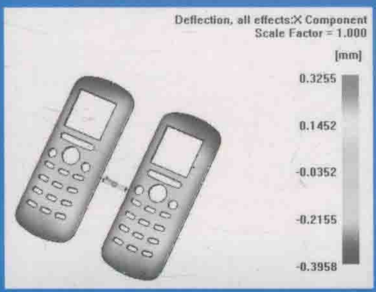
应用型本科机械工程系列精品教材

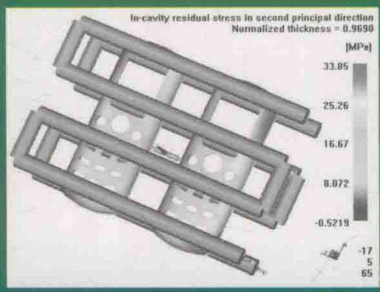
English for Die & Mould Design and Manufacturing

模具设计与制造专业英语









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清华大学出版社

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北京

内容简介

本书是为适应高等学校模具设计与制造专业和机械工程及自动化专业模具方向专业英语教学需要而编写的。本书从模具专业特点出发,并注意吸收现代模具新技术方面的有关知识,涵盖了模具设计与制造的主要内容,包括:冷冲模、塑料模、压铸模、数控加工、模具特种加工、模具CAD/CAE/CAM等。为便于阅读,在编排上各单元相对独立,每节后附有新出现的专业词汇,同时在书后附有模具专业词汇总表。

本书可作为高等学校及高职教育模具设计与制造专业英语教材,也可供有关工程技术人员参考,或作为工具书使用。

图书在版编目(CIP)数据

模具设计与制造专业英语/王家惠,郑兴睿主编. —北京:清华大学出版社,2017
(应用型本科机械工程系列精品教材)
ISBN 978-7-302-48065-5

Ⅰ. ①模… Ⅱ. ①王… ②郑… Ⅲ. ①模具-设计-英语-高等学校-教材 ②模具-制造-英语-高等学校-教材 Ⅳ. ①TG76

中国版本图书馆CIP数据核字(2017)第208130号

责任编辑: 赵 斌 赵从棉
封面设计: 常雪影
责任校对: 王淑云
责任印制: 沈 露

出版发行: 清华大学出版社
网 址: http://www.tup.com.cn, http://www.wqbook.com
地 址: 北京清华大学学研大厦A座 **邮 编:** 100084
社 总 机: 010-62770175 **邮 购:** 010-62786544
投稿与读者服务: 010-62776969, c-service@tup.tsinghua.edu.cn
质量反馈: 010-62772015, zhiliang@tup.tsinghua.edu.cn
印 装 者: 三河市少明印务有限公司
经 销: 全国新华书店
开 本: 185mm×260mm **印 张:** 9.25 **字 数:** 221千字
版 次: 2017年12月第1版 **印 次:** 2017年12月第1次印刷
印 数: 1~1000
定 价: 42.00元

产品编号:070494-01

前 言

FOREWORD

21世纪我国将成为制造业强国，与国外交往的机会亦会随之增多，对外学术交流及合作将更加频繁，以英语为载体的专业信息将成倍增长，专业英语的应用亦将越来越广泛。对模具设计与制造专业的研究生、本科学生及专科学生，以及从事模具相关行业的工程技术人员而言，熟练掌握专业英语，对于促进国际交流、了解并熟悉国外模具设计与制造行业的最新发展动态、参与模具产品的国际竞争是十分必要的。模具设计与制造专业英语是模具设计与制造专业的一门重要基础课。随着模具CAD/CAM/CAE技术的发展和互联网的普及，新世纪从事模具设计与制造专业的毕业生不仅要掌握先进模具技术，而且要具备扎实的外语能力。模具设计与制造技术的发展将对模具专业英语教学提出更高的要求，对专业英语的学习亦将更为迫切。为了满足模具设计与制造专业英语教与学的需求，我们编写了《模具设计与制造专业英语》一书。

模具设计与制造是一门交叉学科，内涵丰富，涉及面很广，包括金属材料成形、高分子材料成形、模具材料、模具制造工艺、先进制造方法等内容。在整个编写过程中，为使本教材体现先进性、科学性和实用性，本书从国外最新出版的教科书、专著、外文期刊中筛选资料，把国外较新的研究成果编写进教材中；并根据该课程教学大纲要求，从培养学生阅读能力方面着手，充分考虑了文章的阅读性与知识性，所选资料既考虑了当今模具行业的覆盖面，又反映了其发展趋势。在侧重阅读理解、掌握模具专业常用词汇基础上，突出模具专业特点。课文简单易读，适合不同层次的读者阅读。

本书的选材是在有限的篇幅内尽可能地涵盖模具设计与制造的学科领域。全书共分6章，即冲压工艺及模具设计（Stamping Forming and Die Design）、塑料模具设计（Plastics Molds）、铸造模具设计（Casting Dies）、数控加工（CNC Machining）、模具特种加工（Mold Special Machining）以及模具CAD/CAM/CAE。

本书由昆明理工大学王家惠、郑兴睿任主编。其中王家惠负责全书的结构及第2章，第5章内容的编写；郑兴睿负责第1章，第4章内容的编写；吴承玲负责第3章内容的编写；程良负责第6章内容的编写；万祥明参加了第5章内容的编写；书中插图由万祥明绘制。

本教材在编写过程中，得到了昆明理工大学模具技术研究所的教师和研究生的大力支持，在此表示衷心的感谢。

由于时间仓促，编者水平有限，书中错误之处在所难免，敬请批评指正。

编　者

2017年7月

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Chapter 1

Stamping Forming and Die Design

1.1 Introduction

In today's practical and cost-conscious world, sheet-metal parts have already replaced many expensive cast, and machined products.

The reason is obviously the relative cheapness of stamped, or otherwise mass-produced parts, as well as greater control of their technical and aesthetic parameters. That the world slowly turned away from heavy, ornate, and complicated shapes, and replaced them with functional, simple, and logical forms only enhanced this tendency. Remember old bathtubs ? They used to be cast and had ornamental legs. Today they are mostly made of coated sheet metal, if not plastics. Manufacturing methods for picture frames, and doors were gradually replaced by more practical and less costly techniques.

Metal stamping, probably the most versatile products of modern technology, are used to replace parts previously welded together from several components. A well-designed sheet-metal stamping can sometimes eliminate the need for riveting or other fastening processes. Stampings can be used to improve existing designs that are often costly and labor-intensive. Even products already improved upon, with their production expenses cut to the bone, can often be further improved, further innovated and further decreased in cost.

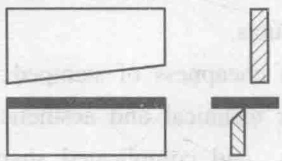
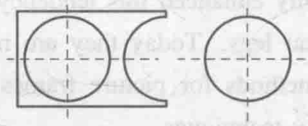
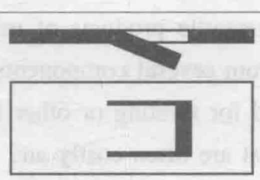
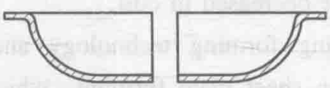
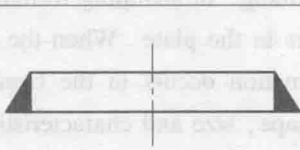
This part focuses on the stamping forming technology and its die design in metal processing. Stamping is mainly used in sheet plate forming, which can be used not only in metal forming, but also in non-metal forming. In stamping forming, under the action of dies, the inner force deforming the plate occurs in the plate. When the inner force reaches a certain degree, the corresponding plastic deformation occurs in the blank or in some region of the blank. Therefore the part with certain shape, size and characteristic is produced.

Stamping is carried out by dies and press, and has a high productivity. Mechanization and automatization for stamping can be realized conveniently owing to its easy operation. Because the stamping part is produced by dies, it can be used to produce the complex part that may be manufactured with difficulty by other processes. The stamping part can be used generally without further machining. Usually, stamping process can be done without heating. Therefore, not only does it save material but also energy. Moreover, the stamping part has the characteristics of light weight and high rigidity.

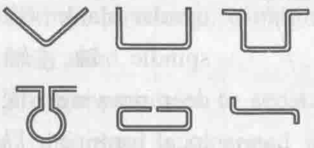
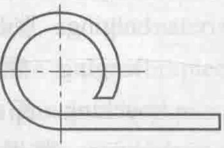
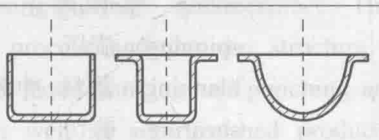
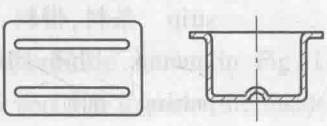
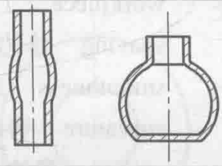
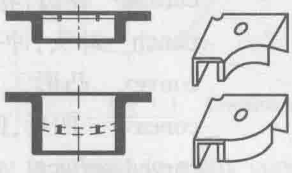
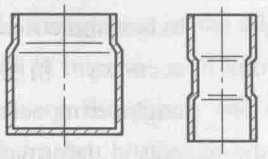
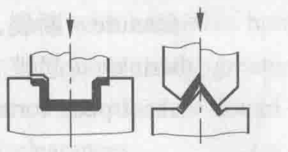
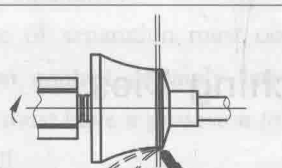
Stamping processes vary with the shape, the size and the accuracy demands, the output of the part and the material. It can be classified into two categories: cutting process and forming process. The objective of cutting process is to separate the part from blank along a given contour line in stamping. The surface quality of the cross-section of the separated part must meet a certain demand. In forming processes, such as bending, deep drawing, local forming, bulging, flanging, necking, sizing and spinning, plastic deformation occurs in the blank without fracture and wrinkle, and the part with the required shape and dimensional accuracy is produced.

The stamping processes widely used are listed in Table 1-1.

Table 1-1 Classification of the Stamping Processes and Their Characteristics

Process		Diagram	Characteristics
Cutting	Shearing		Shear the plate into strip or piece
	Blanking		Separate the blank along a closed outline
	Lancing		Partly separate the blank along a unclosed outline, bending occurs at the separated part
	Parting		Separate various workpiece produced by stamping into two or more parts
	Shaving		A layer of thin chip is shaved along the external side or the inner hole, to improve size accuracy and smoothness of the cross section of shearing

Continued

Process		Diagram	Characteristics
	Bending		Press the sheet metal into various angles, curvatures and shapes
	Curling		Bend ending portion of the plate into nearly closed circle
	Deep drawing		Produce an opened hollow part with punch and die
	Local forming		Manufacture various convex or concave on the surface of the plate or part
	Bulging		Expand a hollow or tubular blank into a curved surface part
Forming	Flanging		Press the edge of the hole or the external edge of the workpiece into vertical str-aight wall
	Necking		Decrease the end or middle diameter of the hollow or tubular shaped part
	Sizing		Finish the deformed workpiece into the accurate shape and size
	Spinning		Form an axis-symmetrical hollow part by means of roller feeding and spindle rotational movement

New Words and Expressions

stamping 冲压,冲压件
sheet-metal parts 钣金零件
aesthetic 工艺的
ornate 华丽的
functional 功能的
bathtub 浴盆
ornamental 观赏的
coated sheet metal 喷涂的板材
welding 焊接
riveting 铆接
fastening 紧固
labor-intensive 劳动密集的
die 模具,砧子,凹模
metal processing 金属加工
metallic engineering science 金属工程科学
plastic forming 塑性成形
machining 机械加工,切削加工
casting 铸造,浇注
plate 板,板材,钢板
blank 毛坯,坯料
press 冲压,压制
mechanization 机械化
automatization 自动化
rigidity 刚性,刚度
roller feed 滚轮送料
cutting process 分离工序
forming process 成形过程,成形工艺
contour 轮廓,外形
cross-section 横截面
bending 弯曲
tubular-shaped 管状的
tubular blank 管状坯料
spindle 轴,主轴
deep drawing 深拉延
local forming 局部成形
bulging 胀形,起凸
flanging 翻口,翻边,弯边
necking 缩颈
sizing 整形,矫正
spinning 旋压
blanking 落料,冲裁
shearing 剪切
strip 条料,带料,脱模
lancing 切缝,切口
parting 剖切,分开,分离
workpiece 工件
shaving 修边,整修
smoothness 光滑(度),平整(度)
curvature 弯曲,曲率
curling 卷边,卷曲
punch 冲头,冲孔
convex 凸形
concave 凹形,凹面
curved-surface 曲面
axis-symmetrical 轴对称的
accuracy 精度
engineering science 工程科学
plastic deformation 塑性变形
fracture 断裂,断裂面
wrinkle 起皱
sheet plate forming 板料成形

1.2 Blanking and Punching Dies

1.2.1 Blanking

Metal cutting is a process used for separating a piece of material of predetermined shape and size from the remaining portion of a strip or sheet of metal. It is one of the most extensively used processes throughout die and sheet-metal work. It consists of several different material-parting operation, such as blanking, punching, trimming, parting and shaving, where punching and blanking are the most widely used.

Blanking and punching are the processes to separate sheet metal along a closing outline. After blanking and punching, the plate is separated into two parts. Punching is to punch a needed hole in a blank or workpiece, and the material punched from the blank is the waste, that is, the part out of the closing outline is the workpiece, and the part in the closing outline is the waste. Oppositely, blanking is to punch a workpiece or blank with needed shape in the plate, that is, the part in the closing outline is the workpiece. The part out of the closing outline is the waste. The deformation process and the die structure are identical in both blanking and punching. Conventionally, both blanking and punching are called blanking. Through blanking process, final product as well as semi-finished product for other forming process can be produced.

In the case of the cushion ring shown in Fig. 1-1, the process to make the circle of $\phi22$ mm is called blanking, and that to make the inside hole of $\phi10.5$ mm is called punching.

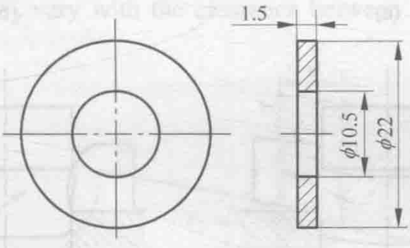


Fig. 1-1 Cushion ring

The actual task of cutting is subject to many concerns. The quality of surface of the cut, condition of the remaining part, straightness of the edge, amount of burr, dimentional stability, all these are quite complex areas of interest, well known to those involved in sheet-metal work.

With correct clearance between the punch and die, almost perfect edge surface may be obtained. This, however, will drastically change when the clearance amount increases, and a production run of rough-edged parts with excessive burrs will emerge from the die.

Highly ductile materials, or those with greater strength and lower ductility, lesser thicknesses or greater thickness—these all were found similarly susceptible to the detrimental effect of greater than necessary clearances.

Naturally, a different type of separation must occur with a softer material than with its harder counterpart. The carbon content certainly has an influence on this process as well. Therefore, the tolerance range must have a provision to change not only with the stock thickness but with its composition as well.

As already mentioned, good condition of tooling is absolutely essential to the cutting process. We may have the most proper tolerance range between the punch and die, and yet the cut will suffer from imperfections if worn-out tools are used.

1.2.2 Blanking Deformation Process

A blanking process involves placing the blank on the die, moving the punch downward to deform and separate the blank with the edges of the punch and die. A clearance Z is existed between the punch and die. The forces of the punch and die applying on the blank are mainly concentrating on the edges of the punch and die.

Blanking deformation process is shown in Fig. 1-2. Under the actions of the punch and die with sharp cutting edges and an appropriate clearance, deformation process undergoes three stages, namely, elastic deformation, plastic deformation and fracture separating stages.

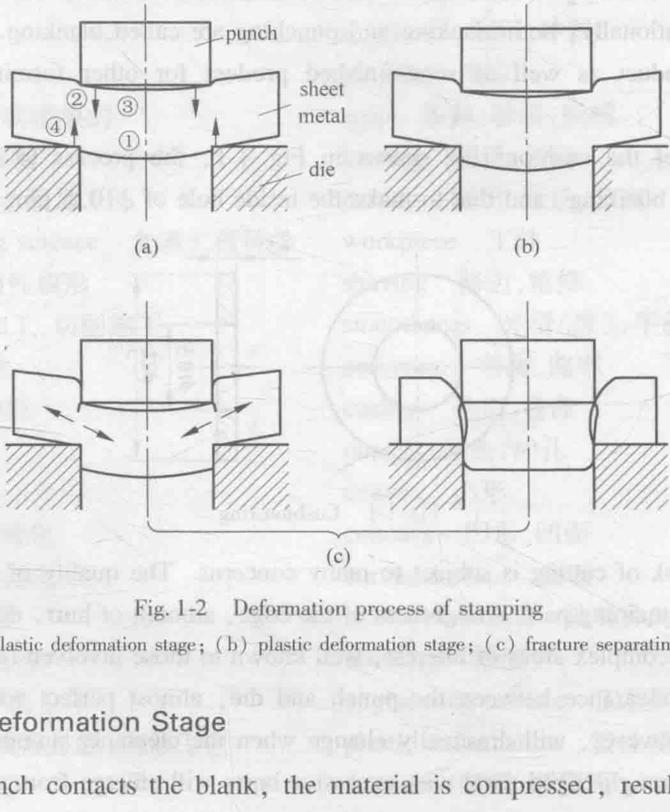


Fig. 1-2 Deformation process of stamping

(a) elastic deformation stage; (b) plastic deformation stage; (c) fracture separating stage

1. Elastic Deformation Stage

When the punch contacts the blank, the material is compressed, resulting in tensile and bending elastic deformation. In this stage, the inner stress hasn't exceeded the elastic limit of the blank yet. The deformation would recover if unloading is occurred.

2. Plastic Deformation Stage

When the punch presses further downward on the blank, the inner stress of the blank reaches its yield strength, the plastic flow and sliding deformation begin to occur. Under the pressure of the punch and die, the surface of the blank is subjected to compression, due to the clearance between the punch and die, the blank is subjected to the actions of bending and tension simultaneously, the material beneath the punch is bended, and that above the die is curled upwards. Circular angles are formed in regions ① and ② due to bending and tension, and indentations appear in regions ③ and ④. While the punch squeeze further into the blank, the plastic deformation and the work hardening in the deformation zone increase further. When the inner stress of the blank near the cutting edge reaches the strength limit of the material, the blanking force reaches its maximum and the cracks occur in the blank, resulting in the damage of the material and the end of the plastic deformation stage (see Fig. 1-2).

3. Fracture Separating Stage

With the punch squeezing into the blank continuously, the cracks at the top and bottom extend to the inner layer of the sheet metal gradually, when the two cracks meet, the blank is cut, and then the process of fracture is ended.

Equilibrium of forces in the shearing zone during blanking is shown in Fig. 1-3; where F_1 and F_2 are the acting forces of the punch and die perpendicular to the blank respectively; F_3 and F_4 are the lateral pressures of the punch and die exerting on the blank respectively; μF_1, μF_2 are the frictions on the end surfaces of the punch and die acting on the blank respectively; μF_3, μF_4 are the frictions on the lateral surfaces of the punch and die acting on the blank respectively. The directions of μF_1 and μF_2 vary with the clearance between the punch and die.

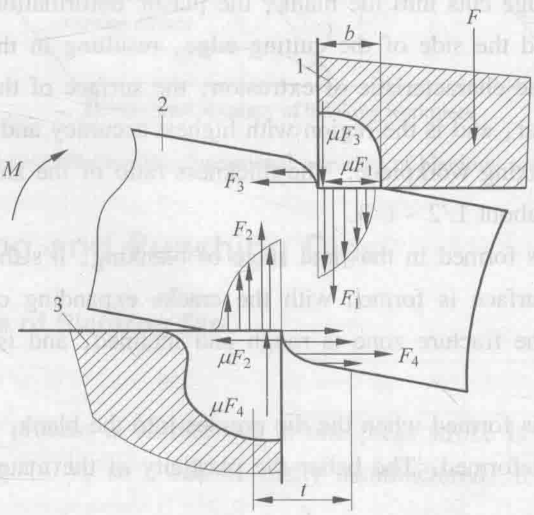


Fig. 1-3 Diagram of the blanking force

1-punch; 2-blank; 3-die

Analysis of the blanking forces shows that the lateral pressures F_3 and F_4 must be smaller than the perpendicular pressures F_1 and F_2; and that the cracks occur and extend more easily in the area of small pressure. Therefore, the initial crack occurs on the side surface of the die in blanking. Observation on crack initiating and developing with scanning electronic microscope shows that when the depth of punch squeezing downward into the material reaches 20% of the blank thickness, the crack occurs on the side surface of the punch and die edges, and then cracks at the top and bottom extend rapidly. When the two cracks meet, the blank is sheared and the process of fracture is ended.

1.2.3 Blanking Workpiece Quality

The quality of the blanking workpiece mainly refers to the qualities of the cutting cross-section and workpiece surface, shape tolerance and dimensional accuracy. The cutting cross-section quality of the workpiece is an important factor to determine whether the blanking process is succeeded or not.

As shown in Fig. 1-4, the cutting cross-section can be divided into four regions: the smooth sheared zone, fracture zone, rollover zone and burr zone.

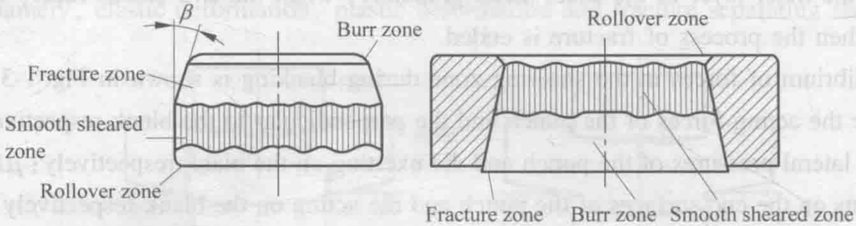


Fig. 1-4 Characteristic of the cutting cross-section of blanking workpieces

When the punch edge cuts into the blank, the plastic deformation occurs due to extrusion between the material and the side of the cutting edge, resulting in the forming of the smooth sheared zone. Due to the characteristic of extrusion, the surface of the smooth sheared zone is smooth and perpendicular, and is the region with highest accuracy and quality within the cutting cross-section of the blanking workpiece. The thickness ratio of the smooth sheared zone to the cutting cross-section is about 1/2 ~ 1/3.

The fracture zone is formed in the final stage of blanking, it's the area where blank is cut off, and the fracture surface is formed with the cracks expanding continuously under tensile stress. The surface of the fracture zone is rough and inclined, and is not perpendicular to the blank.

The rollover zone is formed when the die presses into the blank. The material near cutting edge is embroiled and deformed. The better the plasticity of the material, the larger would be the rollover zone.

The burr of the cutting cross-section is formed when micro-cracks occur during blanking. The formed burr is then elongated and remains on the workpiece.

There are many factors affecting the quality of the cutting cross-section. The proportion of the thickness of the four zones (smooth sheared zone, fracture zone, rollover zone and burr zone) varies with blanking conditions, such as workpiece material, punch and die, equipment, etc.

Fig. 1-5 shows the main factors that affect the quality of the cutting cross-section of blanking workpiece. Fig. 1-6 shows those factors affecting the dimensional accuracy of blanking workpiece. The research and analysis show that the clearance between the punch and die is the most important factor affecting the surface quality and the dimensional accuracy of the blanking workpiece. To increase the surface quality of the blanking workpiece, it is important to study the clearance influence mechanism, so as to find a method for calculating the optimal clearance between the punch and die.

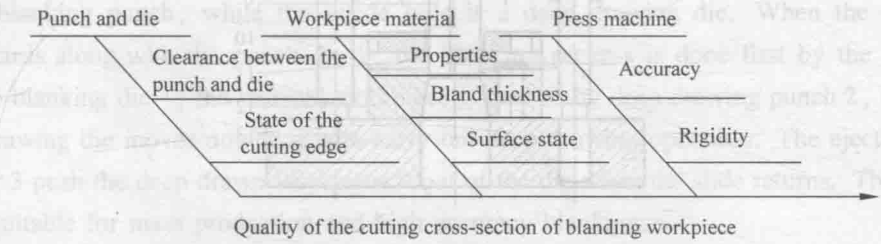


Fig. 1-5 Factors affecting the quality of the cutting cross-section of blanking workpiece

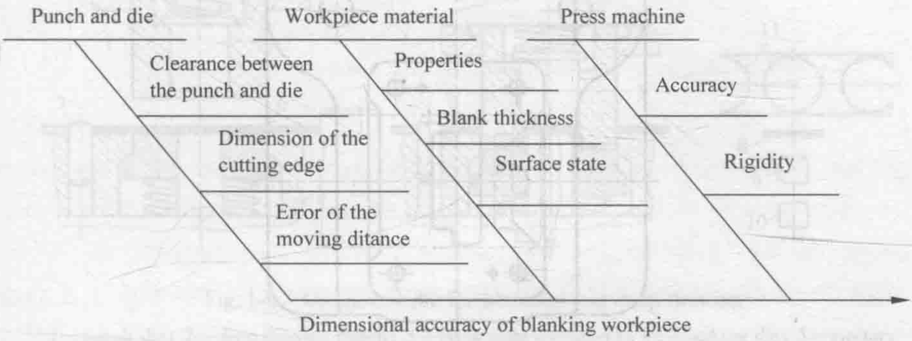


Fig. 1-6 Factors affecting the dimensional accuracy of blanking workpiece

1.2.4 Blanking and Punching Dies

1. Typical Structure of Blanking Die

(1) Simple Die

The die that only one process is carried out in one press stroke is called simple die. Its structure is simple (see Fig. 1-7), so it can be easily manufactured. It is applicable to small batch production.

(2) Progressive Die

The die that several blanking processes are carried out at different positions of the die in one press stroke is called progressive die, as shown in Fig. 1-8. In the operation, the locating pin 2 aims at the locating holes punched previously, and the punch moves downwards to punch by punch 4 and to blank by punch 1, thus the workpiece 8 is produced. When the punch returns, the stripper 6 scrapes the blank 7 from the punch 4, the blank 7 moves forward one step and then the second blanking begins. Above steps are repeated continually. The step distance of the blank is controlled by a stop pin.

most important factor affecting the surface quality and the dimensional accuracy of the blanking workpiece. To increase the surface quality of the blanking workpiece, it is important to study the clearance influence mechanism, rules, and methods of calculating the optimal clearance between the punch and die.

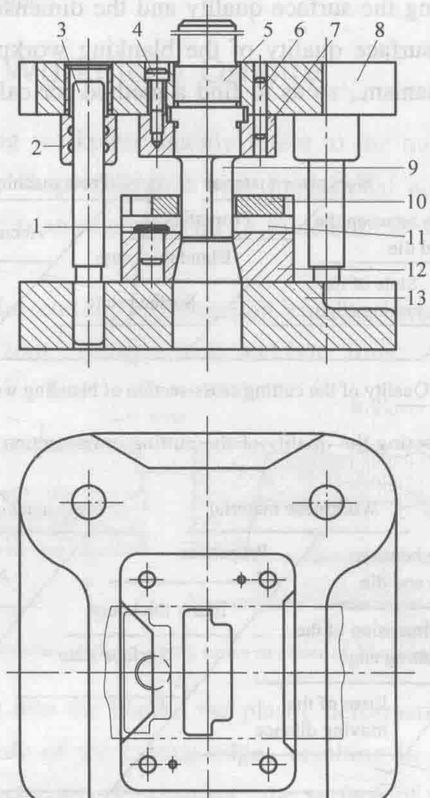


Fig. 1-7 Simple die

1—stop pin; 2—guide bushing; 3—guide pin; 4—bolt; 5—shank; 6—pin; 7—fixed plate; 8—upper bolster; 9—punch; 10—stripper; 11—stock guide; 12—die; 13—lower bolster

1.2.4 Blanking and Punching Dies

1. Typical Structure of Blanking Die

(1) Simple Die

The die that only one process is carried out in one press stroke is called simple die. Its structure is simple (see Fig. 1-7), so it can be easily manufactured. It is applicable to small batch production.

(2) Progressive Die

The die that several blanking processes are carried out in different positions of the die in one press stroke [illegible], the locating pin 2 aims at the locating hole punched previously, and the punch moves downwards to punch by punch 4 and to [illegible] the workpiece 8 is produced. When the punch returns, the stripper 6 scrapes the blank 7 from the punch 4, the blank 7 moves forward one step and then the second [illegible]. The step distance of the blank is controlled [illegible]

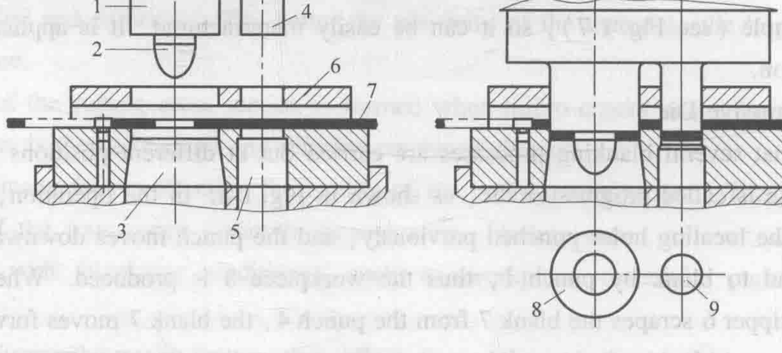


Fig. 1-8 Progressive die for blanking and punching

1—blanking punch; 2—pilot; 3—blanking die; 4—punching punch; 5—punching die; 6—stripper; 7—blank; 8—workpiece; 9—waster