Simplified Metal Works

金工操作

战 盈 王朝辉 编

西北工業大學出版社

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Foreword

To teach any subject, especially in higher learning, textbooks are usually a necessity. For the study of chemistry, physics, mathematics, etc. in the classroom and the laboratory, there are well-written textbooks to guide the student progressively through elementary and advanced principles. It is unimaginable even for Chinese students to study any course without a good textbook. It is more so for students study in a foreign country, where the language poses a great barrier.

However, in this modern era of machining, international students and teachers of metal works often found themselves caught in a helpless situation: the lack of English metal work textbooks makes it impossible for such lessons to go on. On the one hand, the teacher doesn't have a suitable English textbook to lecture and impart their knowledge; on the other hand, international students have to go with Chinese textbooks which they might not know even a single Chinese word.

To meet the urgent demand for such a textbook, the author compiled a Simplified English Metal Works with a view to offering a much needed assistance to those who are handicapped by textbooks.

Owing to the limited space and content, this book is by no means comprehensive, which an experienced reader may find wanting in many ways, however, if the book can give international students a glimpse of what metal works pertains to, of its scope and application within 1 or 2 weeks of workshop practice, then, this book can be deemed as satisfying for the purpose.

Given the academic level of international students and their teachers' language skill, as well as the class requirement, this book will focus more on operations instead of theoretical pedagogy.

The authors

May 2014

Contents

Chapter 1 Basic Properties of Metals

Teaching Objectives

Students are supposed to know the general properties of some most commonly used metals such as cast iron, machine steel, tool steel, high speed steel, brass and copper, and understand theheat treatment of them.

1.1 Basic Properties of Most Commonly Used Metals in Metal Practice

Of primary focus in metal works are such general properties of metals and their alloys as hardness, brittleness, malleability, ductility, elasticity, toughness, density, fusibility, conductivity, contraction and expansion. Such properties form the fundamental theoretical basis for further discussion of metal works. The following table lists some general information of the metals we commonly employed in daily metal works (Table 1.1).

Table 1.1 Metal Working Metals

Metal	Carbon Content/(%)	Appearance	Uses
Cast Iron (C.I.)	2.5 to 3.5	Grey, rough sandy surface	Parts of machines, such as lathe beds, water pump pitcher type, etc.
Machine Steel (M.S.)	0.10 to 0.30	Black, scaly surface	Bolts, rivets, nuts, machine parts
Cold Rolled (C.R.S.)	0.10 to 0.30	Dull silver, smooth surface	Shafting, bolts, screws, nuts
Tool Steel (T.S.)	0.60 to 1.5	Black, glossy	Drills, taps, dies, tools
High Speed Steel (H.S.S.)	Alloy Steel	Black, glossy	Dies, taps, tools, drills, toolbits
Brass		Yellow (various shades), rough if cast, smooth if rolled	Bushings pump parts, ornamental work
Copper		Red-brown, rough if cast, smooth if rolled	Soldering irons, electric wire, water pipes

To better understand the uses of them, the following metal properties are often described.

1.1.1 Melting Point

The melting point is the temperature at which a material starts to melt (Table 1.2).

Table 1.2 Melting Point of Common Metals (℃)

Ferrous	1 536
Copper	1 083
Lead	327
Aluminum	658
Tin	232
Tungsten	3 387

1.1.2 Electrical Conductivity

This feature describes the ability of a metal to conduct electricity (Table 1.3).

Table 1.3 Electrical Conductivity of Common Metals

Copper	100%
Silver	106%
Lead	8%
Aluminum	62%
Ferrous	17%
Zinc	29%

1.1.3 Density

Density gives the quotient of mass and volume of a body (Table 1.4).

Table 1.4 Density of Common Metals (kg/m^3)

Water	1.00
Copper	8.90
Lead	11.30
Aluminum	2.70
Steel	7.85
Tungsten	19.27

1.1.4 Thermal longitudinal Expansion

There is a coefficient describe such properties, with the length of 1 meter at a change of temperature of 1 degree Celsius (Fig. 1.1).

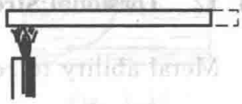


Fig. 1.1

1.1.5 Elasticity

Concerns metal's ability to return to its former shape after distortion. Heat - treated springs are good examples.

1.1.6 Ductility

Is the ability of a metal to be deformed for good without breaking. Examples may include copper and machine steel, which can be drawn into wire, are ductile (Fig. 1.2).

Fig. 1.2

1.1.7 Tensile Strength

Metal ability to resist fracture under tensile load (Fig. 1.3).

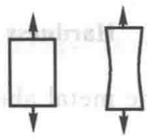


Fig. 1.3

1.1.8 Compressive Strength

The ability to withstand heavy compress load (Fig. 1.4).

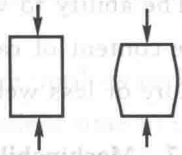


Fig. 1.4

1.1.9 Brittleness

The property of a metal that allows no permanent distortion before breaking. Cast iron is brittle, which breaks rather than bends under shock or impact (Fig. 1.5).

1.1.10 Toughness

The opposite of brittleness, the metals ability to withstand shock or impact (Fig. 1.5).

Fig. 1.5

1.1.11 Shear Strength

Metal ability to resist fracture under shear load (Fig. 1.6).

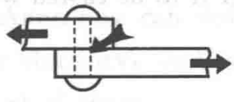


Fig. 1.6

1.1.12 Torsional Strength

Metal ability to resist torsional force (Fig. 1.7).

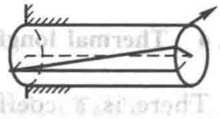


Fig. 1.7

1.1.13 Flexural Strength

The ability to resist under flexural force (Fig. 1.8).

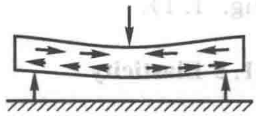


Fig. 1.8

1.1.14 Collapsing Stress

The metal ability to resist axial directed force (Fig. 1.9).

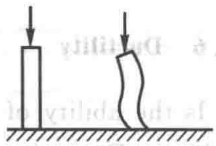


Fig. 1.9

1.1.15 Hardness

The metal ability to withstand abrasion or penetration (Fig. 1.10).

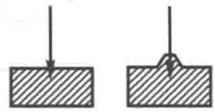


Fig. 1.10

1.1.16 Weldability

The ability to weld 2 metals together. Weldability depends on the content of carbon. Steels with a content of max 0.22% are more or less weldable.

1.1.17 Machinability

Indicates how easy materials can be machined (Fig. 1.11).

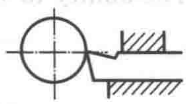


Fig. 1.11

1.1.18 Malleability

Is the property of metals that allows it to be hammered or rolled into other sides and shapes (Fig. 1.12).

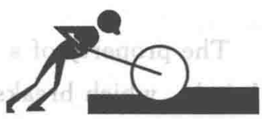


Fig. 1.12

1.1.19 Castability

Is the property of metals that allows it to be molten and after it to be casted without any pores (Fig. 1.13).

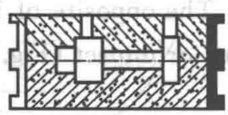


Fig. 1.13

1.1.20 Hardenability

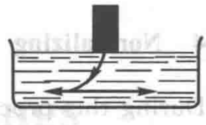


Fig. 1.14

Is the property of iron metals that allows it to increase the hardening through structural transformations (Fig. 1.14).

1.2 Heat Treatment of Metals

Sometimes, the metals and alloys we are working with may not possess all the desired properties. To make them what we want, alloying and heat treatment are often used to improve the material properties.

By way of heat treatment, the microstructures of materials are modified and transformed, which lead to changes of mechanical properties, like strength, ductility, toughness, hardness and wear resistance. The purpose of heat treatment is to prepare the material for improved manufacturability

Heat treatment can be classified into the following types: hardening, annealing, normalizing, tempering and surface hardening.

1.2.1 Hardening

By heating up a metalor an alloy to a certain temperature and then cooling it rapidly, we can add strength and hardness to it.

In this process, take steel for example, steel is heated and held there until its carbon is dissolved, and then cooled rapidly in a way the carbon does not get sufficient time to escape and get dissipated in the lattice structure. This helps in locking the dislocation movements when stresses are applied.

1.2.2 Quenching

Sometimes we can cool hot metal rapidly by immersing it in brine (salt water), water, oil, molten salt, air or gas which in turn resulted in residual stresses (sometimes cracks). Residual stresses are removed by another process called annealing.

1.2.3 Annealing

During annealing, the steel will be heated to 780 - 930℃, and be kept at the temperature for required period of time, then to be cooled slowly. The cooling rate is around 10℃ per hour. The process has to be carried out in a controlled atmosphere of inert gas, to avoid oxidation. It is used to achieve ductility in hardened steels. Annealing can reduce hardness and remove residual stresses, improve toughness, restore ductility, and alter various mechanical, electrical or magnetic properties through refinement of grains.

1.2.4 Normalizing

During this process, the material will be heated above austenitic phase (1 100℃) and then cooled in air. It is similar to annealing but different in cooling methods. The air cooling speeds up the cooling process but leads to enhanced hardness and less ductility.

Normalizing is less expensive than annealing. Different sections of the workpiece will be cooled at different speed, hence the variation in properties.

The selection of which heat treatment is strongly influenced by the carbon content.

1.2.5 Tempering

During this process, the steel is heated to 350 – 400℃, and be kept there for about 1 hour and then cooled slowly at prescribed rate. Tempering is used to reduce brittleness and increase ductility of hardened steel like martensite (very hard and brittle). Tempering can also relieve stresses, hardness, strength and wear resistance marginally in martensite structure.

Exercises

1. How many metal properties can you remember? Can you name a few?
2. What is cast iron?

Chapter 2 Technical Drawings

Teaching Objectives

Students are required to master the basic knowledge of the dimensional description of various shapes and the skills needed, and learn how to do the technical drawing properly.

2.1 Metal Shapes and Description

Due to the wide variety of works in a metal shop, metals are manufactured in various shapes and sizes. Needless to say, there are proper methods for specifying the sizes and dimensions of metals. The following shapes are very common for metal jobs, and each comes with a way to describe them (Fig. 2.1).

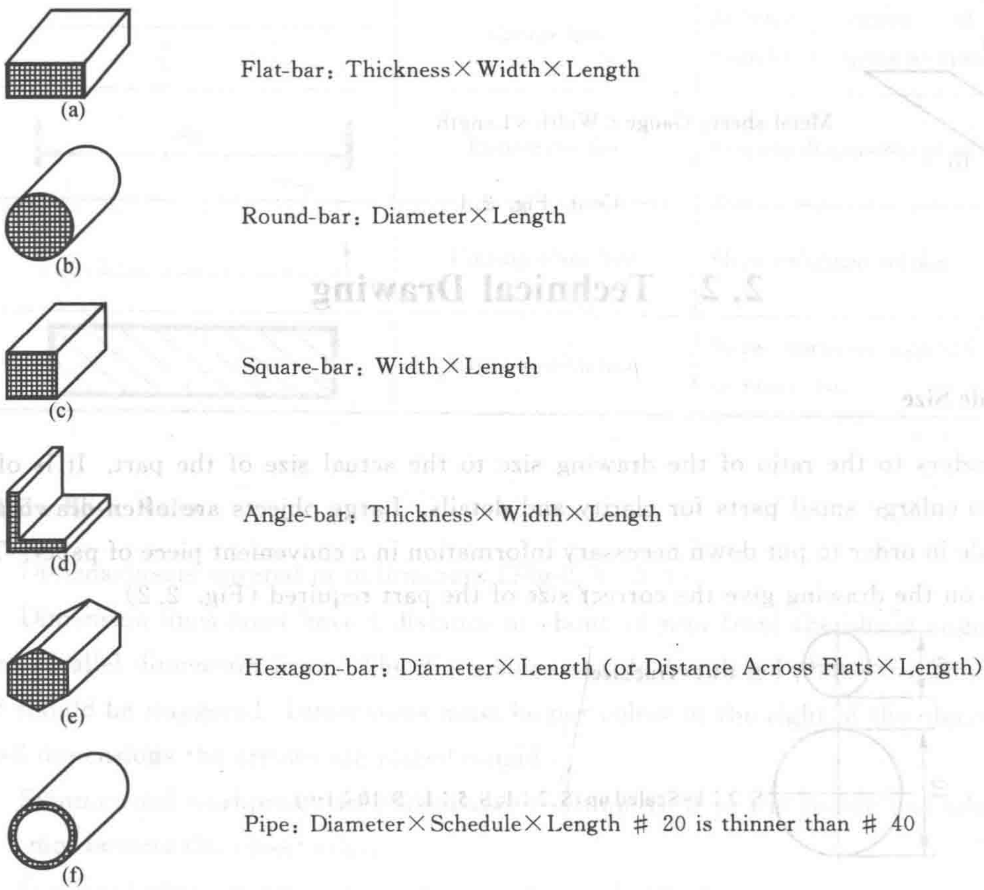
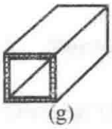
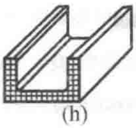


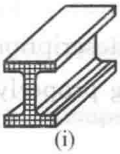
Fig. 2.1



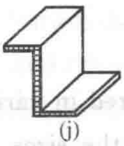
Square-tubing: Thickness × Width × Length



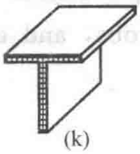
Channel-bar: Width × Height × Length



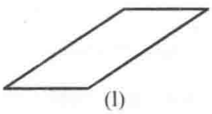
I-beam: Length × Thickness × pounds



Z-bar: Width × Length



T-bar: Width × Length



Metal sheet: Gauge × Width × Length

Cout. Fig. 2.1

2.2 Technical Drawing

2.2.1 Scale Size

Scale refers to the ratio of the drawing size to the actual size of the part. It is often necessary to enlarge small parts for clarity and details. Large objects are often drawn at a reduced scale in order to put down necessary information in a convenient piece of paper. The dimensions on the drawing give the correct size of the part required (Fig. 2.2).

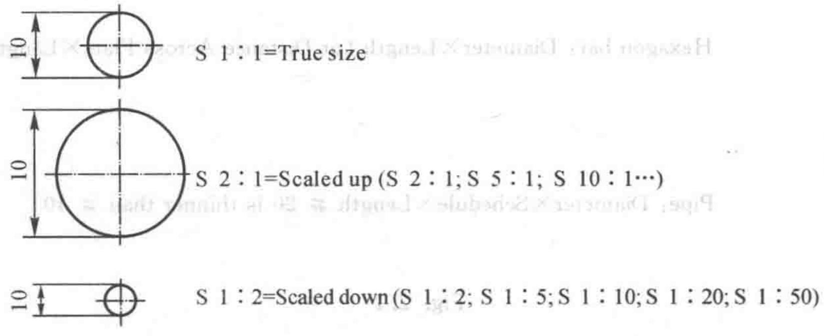
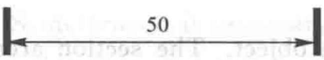
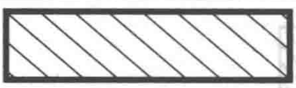


Fig. 2.2

2.2.2 Types of Lines

Technical drawings come with convention and standard to specify precisely what is required. The examples below is the so called "alphabet of lines" (Table 2.1).

Table 2.1 Types of Lines

	Type	Use
	Free-hand line	Sketches; break line
	Object line	Indicate the visible form or edges of an object
	Thin unbroken line	Shading line, thread line, diagonal line
	Hidden line	Indicate hidden contours of an object
	Center line	Indicate centers of holes, cylindrical objects or other sections
	Dimension line	Indicate dimensions of an object
	Cutting-plane line	Show imagined section
	Cross-section line	Show surfaces exposed when a section is cut

2.2.3 Basic Rules

Dimensionsare entered in millimeters (Fig 2.3 - 2.9).

Dimension lines must have a distance of about 10 mm from the object edge and 7 mm from parallel dimension lines. The dimensions should be placed above the dimension lines and should be staggered. Dimensions must be put below or the right of the object edge. For small dimensions the arrows are placed outside.

Symmetrical workpieces are dimensioned symmetrical to the center line which extends 2 - 3 mm beyond the object edge.

Simple workpieces are usually drawn in front elevation.

If the area of a circle appears as a straight line, the diameter symbol must be placed in front of the dimension figure. If the circle is shown in the elevation, then the symbol is not necessary.

A radius is symbolized by R and has only 1 dimension arrow at the circumference. The center point is fixed by the crossing of center lines.

Concealed edges are drawn as dash lines. If visible and hidden edges coincide, the visible edges are drawn.

Fig. 2.3

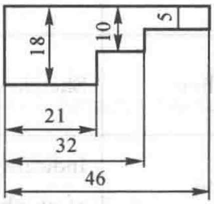


Fig. 2.4

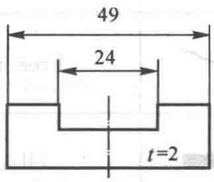


Fig. 2.5

Fig. 2.6

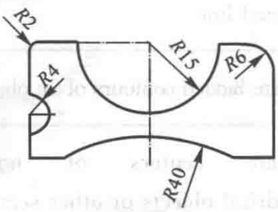


Fig. 2.7

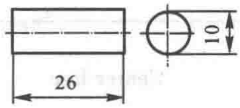


Fig. 2.8

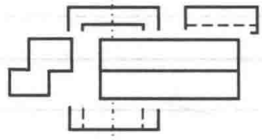


Fig. 2.9

Section views are used to show the interior form of an object. The section areas are shaded, not the hollow spaces. The shading lines are thin unbroken lines, which are angled at 45 degree to the center line or angled to the base edge.

In order to insert dimension figures the shading has to bebroken (Fig. 2.10 – 2.15).

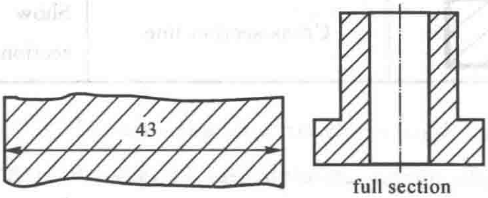


Fig. 2.10

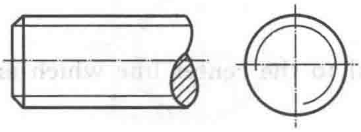


Fig. 2.11

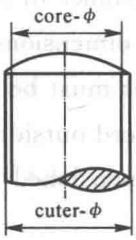


Fig. 2.12

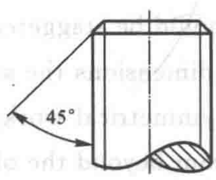


Fig. 2.13