Injection Mold Material Standard

1. Application Scope

This standard stipulates the selection of die design materials for Five-Star Tooling Co., Ltd. According to the function and importance of mould parts, it is selected in this standard according to four situations: must implement, recommend to implement, implement according to customer's requirement, and select according to the routine without restriction of this standard.

Material selection according to the principle of material selection stipulated in this standard can achieve reasonable material selection, compression of varieties, reduction of specifications, simplification of supply channels, reduction of blank materials and stock backlog under the condition of ensuring the quality of dies.

This standard is applicable to the selection of ferrous metals (steel, copper and aluminium) in the process of die design and manufacture by Five-Star Tooling Co., Ltd. This standard is not applicable to the selection of non-metallic materials such as plastics and plastics.

2. Reference

Application Manual of Mold Industry Standards Hong Kong Productivity Council

Die Steel Manual Ministry of Metallurgical Industry Press

Mechanical Design Manual Chemical Industry Press

3. General Rules on Material Limitation

3．1 Principles in selecting materials

a. Material selection should generally be based on the principle of meeting product functions and production requirements.

b. Under the condition of satisfying the quality of mould, don't increase the cost of material at will, but take saving resources as the principle.

c. Material for suppliers with abundant supply and credibility should be selected.

3．2 Influencing factors when selecting injection mould materials

3．2．1 Influencing factors of injection moulded products

a. Whether plastic products will have corrosive effects on materials during injection

b. The influence of the type of plastic resin on steel.

c. Requirements on steel regarding different amount of production.

d. The requirement on materials for plastic parts'appearance quality.

3．2．2 Material Requirements of Moulds

a. Good machinability (including machinability, good electrical machinability, good polishing characteristics and solubility)

b. Requirements for hardness and pre-hardness (including pure and uniform internal structure, heat treatment and surface treatment).

c. Easy to repair when the mould breaks down and has good weldability.

4. Specific Requirements on Material Limitation

According to the characteristics of injection mold and the function and importance of its parts, the parts of injection mold are divided into forming parts, embryo parts and structural components. The restrictions on the selection of die materials can be divided into the following four situations:

a. Formed parts such as cavity insert, core insert, lifter, ejector bar, cavity small insert, core small insert, slide insert, etc. The selection principle of formed parts belongs to the recommended implementation. The limited materials are detailed in Table 2, Table 3 and Table 4.

b. Mold base components like top and bottom clamp plate, A plate, B plate, spacer plate, ejector plate,etc. The selection principle of embryo module belongs to the compulsory restriction of selection. The limited materials are detailed in Table 5.

c. Structure components such as wear plate, nozzle, retaining block, etc. The selection principle of structural components must be implemented. If customers have special requirements, they should be advised to accept our opinions. The limited materials are detailed in Table 6.

d. Except for the three cases mentioned above, the principle of selecting materials for all components and components is not stipulated, and they are selected according to the previous routine.

※ For the convenience of searching data and selecting materials, the classification and material number of general die materials are listed in Table 1.

Table 1: General Mould Material Classification and Material Brand

Category	AISI	Brand	Material No.
STEELS	1050、1055 (DIN：1.1730) (JIS：S50C、S55C) (GB:50#、55#)		
PLASTIC MOULD STEELS	P20 (DIN：1.2311) (DIN：1.2738) (JIS：SCM) (GB：3Cr2MoS)	ASSAB：	718S、718H、618
		DAIDO：	PX88、PX4、PX5、NAK80、NAK55
		SAARSTAHL：	GS2738、GS2311、GS2312、GS2711
		THYSSEN：	P-20M、GS-738、GS-711
		BOHLER：	M202、M201、M238、M461
	420 (DIN：1.2083) (DIN：1.2316) (JIS：SUS420J2) (GB：3Gr13)	ASSAB：	S136、S136H、S136 ESR、S136H ESR
		DAIDO：	S-STAR、S-STAR(A)、440C
		SAARSTAHL：	GS2083、GS2083H、GS2083 ESR、GS2316
		THYSSEN：	GS-083 ESR、GS-361、 GS-316 ESR、
		BOHLER：	M300 ESR、M310 ESR、M310H ESR、M330 VAR
HOT WORK STEELS	H13 (DIN：1.2344) (JIS：SKD61) (GB：4Gr5MoSiV1)	ASSAB：	8407、8402
		DAIDO：	DH2F、DH31-S、DHAI(HI)
		SAARSTAHL：	GS2344、GS2344 ESR、GS2767
		THYSSEN：	GS-344EFS、GS-344ESR、GS-344M
		BOHLER：	W302、W303
COLD WORK STEELS	01 (DIN：1.2510) (JIS：SKS3) (GB：9GrWMn)	ASSAB：	DF-2、DF-3
		SAARSTAHL：	GS2510
		THYSSEN：	GS-510
		BOHLER：	K460
		DAIDO：	GOA
	D2 (DIN：1.2379) (JIS：SKD11) (GB：Gr12MoV)	ASSAB：	XW-41、XW-42
		DAIDO：	DC11、DC53
		SAARSTAHL：	GS2379
		THYSSEN：	GS-379、GS-821
		BOHLE：	K110
	D3 (DIN：1.2080) (JIS：SKD1) (GB：Gr12)	ASSAB：	XW-5
		SAARSTAHL：	
		BOHLER：	K100
Permeable steel	Permeable steel	新东：	Porcerax II PM-35
NON-FERROUS METAL	Alloy copper	AMPCO：	AMPCO940
	BeCu	BRUSH WELLMAN：	MAX30、MAX40
	LFAD BRONZE	LFAD BRONZE	
	Pure copper		
	Alloy Al	ALCOA	6061-T651、7055-T651
		ALCAN：	7022-T651
		MELCHERS	WELDURAL、HOKOTOL、GIANTAL

※ In BOM, specific brand of the material of forming parts should be pointed out , instead of mentioning the category of the material, such as P20, H13, 420, etc. If only mention the category of the material, it should be understood that there is no specific requirement for the type of material, and the supplier can choose any material supply in this large category.

Table 2: Material Selection Table of Steel for Injection Molding Parts (Reference by Desheng)

Resin	Mold Requirement			Die Life Requirements	AISI Standard	Suggested Die Steel Material (Desheng Steel)	HRC
	Anti-corrosion	Wear-resisting	Tensile				
ABS	No	Low	High	100,000	6F7	GS-767+heat treatment	50-54
					P20+VAR	GS-808VAR	38-42
					P20(SUPER)	GS-711+heat treatment	50-54
				50,000	P20(SUPER)	GS-711	35-38
				10,000	P20+Ni	GS-738	32-35
ABS+ Wear Resista	Mid	Mid	High	100,000	420Mod ESR	GS-316ESR+heat treatment	45-48
				50,000	420	GS-083M	32-35
				10,000	P20(SUPER)	GS-711+nitridation	HV680-720
PVC	High	Low	Low	100,000	420Mod ESR	GS-316ESR+heat treatment	45-48
				50,000	420Mod	GS-316	28-32
				10,000	420 预硬	GS-083H	30-33
HIPS	No	Low	Mid	100,000	P20+VAR	GS-808VAR	38-42
					P20(SUPER)	GS-711+heat treatment	50-54
				50,000	P20+Ni	GS-738	32-35
				10,000	~P20	P20M	30-35
HIPS+ GPPS	No	Low	Mid	100,000	P20+VAR	GS-808VAR	38-42
					P20(SUPER)	GS-711+heat treatment	50-54
				50,000	P20(SUPER)	GS-711	35-38
				10,000	P20+Ni	GS-738	32-35
GPPS	No	Low	Mid	100,000	P20+VAR	GS-808VAR	38-42
					P20(SUPER)	GS-711	35-38
				50,000	P20+Ni	GS-738	32-35
				10,000	~P20	P20M	30-35
PP	No	Low	High	100,000	6F7	GS-767+heat treatment	50-54
				50,000	P20(SUPER)	GS-711	35-38
				10,000	P20+Ni	GS-738	32-35
PC	No	Mid	High	100,000	420ESR	GS-083ESR+heat treatment	48-52
					6F7	GS-767+heat treatment	50-54
				50,000	P20+VAR	GS-808VAR+nitridation	HV680-720
					P20(SUPER)	GS-711+nitridation	HV680-720
				10,000	P20+Ni	GS-738+nitridation	HV680-720
POM	High	Mid	High	100,000	440ModESR	GS-361ESR+heat treatment	54-58
				50,000	420ModESR	GS-361ESR+heat treatment	45-48
				10,000	420ModESR	GS-361ESR	28-37
SAN	Mid	Mid	High	100,000	420ESR	GS-083ESR+heat treatment	48-52
				50,000	420Pre hardeningESR	GS-083M	32-35
				10,000	420Pre hardening	GS-083H	30-33
PMMA	Mid	Mid	High	100,000	420ESR	GS-083ESR+heat treatment	48-52
				50,000	420Pre hardeningESR	GS-083M	32-35
				10,000	420Pre hardening	GS-083H	30-33
PA	Mid	Mid	High	100,000	440ModESR	GS-361ESR+heat treatment	52-56
					420ModESR	GS-361ESR+heat treatment	45-48
				10,000	420ModESR	GS-361ESR	29-33
				10,000	420Mod	GS-361	28-32
LDPE	No	Low	Mid	100,000	P20(SUPER)	GS-711	35-38
				50,000	P20+Ni	GS-738	32-35
				10,000	~P20	P20M	30-35
HDPE	No	Low	Mid	100,000	P20+VAR	GS-808VAR	38-42
					H13	GS-344HT+heat treatment	47-49
				50,000	P20(SUPER)	GS-711	35-38
				10,000	P20+Ni	GS-738	32-35

※English abbreviations and annotations:

EFS	Normal
ESR	Electroslag remelting process
VAR	Vacuum refining process
Mod	Improved
SUPER	Super

Table 3: Contrast table of special steel for moulds in different countries (and brands)

Category	International Number	Contrast of Special Steel Products of Different Countries (and Brands)								
Plastic Mould Steel	AISI	DIN	GB	JIS	ASSAB	SAARSTAHL	Thyssen	Bohler	DAIDO	HITACHI
	P20	1.2311	3Cr2Mo	SCM	-618	GS2311 GS2312	P-20M GS-312	M202 M201	PX4 PX5	HPM2
	P20+Ni	1.2738	4Cr2MoNi	SCM	718	GS2738	GS-738	M238	PX88	HPM7
	P21	-	15Ni3Mn	SCM	718H	-	GS-808 VAR	M261 M461	NAK55 NAK80	HPM1 CENA1 HPM50
	420	1.4028	-		-	GS4028		M330 VAR		-
	420	1.2316	4Cr17NiMoMn	SUS	S136H	GS2316		M300 ESR	S-STAR	HPM-38
	420	1.2083	3Cr13		S136	GS2083		M310 ESR	S-STAT(A)	-
Hot Work Steel										
	HT13	1.2344	4 Cr 5MoSiV1	SKD61	8407 8402	GS2344	GS-344	W302 W302	DHAI(HI)	DAC FDAC
	H13 Mod	-	-	SKD61	DIEVAR	-	GS-367	-	DH31-S DH2F	DAC55
	H10	1.2855	-	SKD7	QRO90 HOTVAR	GS2855	GS-885	W321	DH72	YEM
	H11	1.2343	4Cr5MoSiV	SKD6	VD11	GS2343	GS-343	W400 VAR		-
	H19	-	-	SKD8	-	-	-	W108	DH41	MDC
	H21	1.2581	3Cr2W8V	SKD5	-	GS2581	-	W100	DH5	HDC
Cold Work Steel	O1	1.2510	9CrWMn	SKS3	DF2 DF3	GS2510	GS-510	K460	GOA	SGT
	D2	1.2379	Cr12Mo1V1	SKD11	XW-41 XW-42	GS2379	GS-379	K110	DC11 DC53	SLD SLD8
	D3	1.2080	Cr12	-	-	GS2080	GS-080	K100		-
	D6	1.2436	Cr12W	-	XW-5	GS2436	GS-436	K107		-
	S7	-	-		-	-	-	K340		-
High Speed Steel	M2	1.3343	W6Mo5Cr4V2	SKH51	KM-2	GS3343	GS-388	S600	MH51	YXM1

Table 4: Material Limitation for Molding Parts

Material Selection for CAVITY INSERT、CORE INSERT、SLIDE BLOCK、CAM、 EJECTOR BAR、STRIPPER BAR、CAVITY SMALL INSERT、CORE SMALL INSERT、SLIDE INSERT、CAM INSERT、EXCHANGEABLE INSERT、RUNNER INSERT：

Mold Life Requirement		Die Characteristic Requirements	Applicable die steel (copper) brand:					
			ASSAB	DAIDO	SAARSTAHL	BOHLER	THYSSEN	Others
Prehardened steel	10,000	General	618	PX4	GS2311	M202	P-20M	SP300
		High polishing						
		Mirror polishing						
	50,000	General (High polishing, high tensile strength and high toughness)	718S、718H	NAK55	GS2738	M238	GS-738	SP400 MEK4
		High corrosion resistance	168		GS2316H		GS-316S	
		High polishing	S136H	NAK80	GS2316	M300		
		Mirror polishing Corrosion resistance	S136H SUP	S-STAR	GS2083H	M300 ESR M310H ESR	GS-083H	
		High toughness			GS2711		GS-711	
Heat Treated Steel	100,000	General (High wear resistance, high tensile strength and high toughness)	8402 8407	DH2F DH31-S DHAI(HI)	GS2344 GS2344 ESR	W302 W303	GS-344 EFS GS-344 ERS	
		High Corrosion Resistance			GS2316		GS-316 GS-316 ESR	
		High polishing						
		Mirror polishing Corrosion resistance	S136 S136 SUP	S-STAR (A)	GS2083 VAR	M310 ESR M330	GS-083 ESR	
		High wear resistance	XW-41 XW-42			K110	GS-379 GS-821	
		Wear resistance and toughness	635 XW-10					
		Mirror polishing and corrosion resistance	POLMAX			M333	GS-083 VAR	
Copper	-	High thermal conductivity	AMPCO940					
		High hardness and thermal conductivity	MAX30、MAX40					

※ CAVITY INSERT PIN、CORE INSERT PIN、SLIDE INSERT PIN、CAM INSERT PIN In principle, the standard parts are required to be reformed. If the standard parts are not feasible, the forming steel is selected according to the requirements of the die.

※ Materials for CAVITY CLAMP and CORE CLAMP：1050、P20、01,

※ Choose Desheng Materials should write a extra GS like GS273; components other than CAVITY CLAMP and CORE CLAMP should have specific material type,

Table 5: Material limitation for mould base components

Components	Material Type	Remark
TOP CLAMP PLATE	1050、P20	
SPACER PLATE	1050、P20	
RUNNER STRIPPER PLATE	1050、P20	
“A” PLATE	1050、P20	The original "A" platform chooses steel according to the requirements of forming parts, as shown in Table 3.
STRIPPER PLATE	1050、P20	
“B” PLATE	1050、P20	The original "B" plate is made of steel according to the requirements of forming parts. See Table 3.
“B1” PLATE	1050、P20	
“B3” PLATE	1050、P20	
SUPPORT PLATE	1050、P20	
SPACER BLOCK	1050、P20	
EJECTOR PLATE	1050、P20	
EJECTOR RETAINER PLATE	1050、P20	
BOTTOM CLAMP PLATE	1050、P20	

※Mold base components should use steel under AISI standard like P20, if not clarified, Chinese P20 is preferred.

Table 6: Material Limitation of Mould Structural Components

Category	Components	Material Type	Remark
Gating System	LOCATING RING	1050	
	SPRUE BUSHING	01、1050(carburization)、MAX30	
	SPRUE BUSHING LOCATING	1050(carburization) 、01	
	EXTEND SPRUE BUSHING	420、01、1050	
	SPRUE BODY	420、01	
	SPRUE BUSH	1050	
	SPRUE GATE	420、01	
	GATE BUSH	Standard Parts Reform、420、01	
Stripping Mechanism	GIB	01、Brass and graphite	
	WEDGE	1050、P20、01	
	ANGLE BLOCK	1050、P20	
	SQUARE DOWEL	P20、H13	

	FORNICIFORM DOWEL	P20、H13	
	STRIPPER BASE	1050、P20	
	STRIPPER ROD	Standard Parts Reform、P20	
	EJECTOR BASE	1050、P20	
	LINK BAR	P20、Standard Parts Reform	
	CAM GUIDE BLOCK	Cup copper	
	CAM SLIDE BLOCK	01、P20	
	CAM BASE	1050、P20	
	RETAINING BLOCK	1050	
	SUPPORT PIN	1050	
	EJECTOR ROD	P20	
	LOCATING SET	Cup copper	
Locating Components	CLAMP	1050、P20	
	MAT	1050、P20	
	BACK-UP PLATE	1050、P20	

Table 7:

Category	Components	Material Type	Remark
Locating Components	STOPPER	1050	
	LIMITED WASHER	1050	
	LOCK BLOCK	01、Standard part	
	P/L LOCK （FEMALE/MALE）	01、Standard part	
	P/L LOCK （FEMALE）	01、Standard part	
	P/L LOCK （MALE）	01、Standard part	
	FLAT KEY	01、Standard part	
	FLAT DOWEL	01、Standard part	
	“U” PIN	01、	
Cooling System	EXTENSION PLUG	Hexagonal copper	
	BAFFLE	Bronze	
	COPPER PRESSURE PLUG	Pure copper	
	COPPER PIN	Pure copper	
	CONNECTOR BLOCK	1050、Al	
	BRANCH BLOCK	1050、Al	
Electrical, Hydraulic and Pneumatic Components	HYDRAULIC LINK	P20	
	BOT. HYD. CYLINDER	1050、P20	
	HYDRAULIC LINK PIN	P20	
	SWITCH PLATE	1050	
Auxiliary Device	GUIDE BLOCK	01、P20	
	GUIDE TRACK	01、P20	
	GUIDE ROD	01、P20	
	“T” GIB	01、Brass and graphite	
	LEVER	1050	
	EARLY RETURN PIN	P20	
	COLLIDE BLOCK	01、P20	
	LATCH BAR	P20	
	LATCH LOCK	01、P20	

	SCREW BUSHING	Standard Parts Reform、Cup copper	
	COPPER BUSH	Cup copper	
	LINK BAR	1050、P20	
	LINK BLOCK	1050、P20	
	SUPPORT PIN	S50C、P20	
	WEAR PLATE	01、Brass and graphite	
	P/L STRAP	1050	
	COVER PLATE	PC	
	HEIGHT SPACER	1050、P20	
	LOCK	01、P20	
	LIFTING BAR	1050	
	COOLING INDICATE PLATE	Brass	
	SUPPORT PILLAR	1050	
	STAND OFF	1050	
	SUPPORT BLOCK	01、P20	
	CALIBRATION BLOCK	P20	
	COPPER BUSH	Brass	
	P/L STRAP	1050	
	PULL BAR	1050	
	CHAIN MOUNT BLOCK	1050	
	CHAIN MOUNT SEAT	1050	
	FIXED BLOCK	1050	
	WIRE CLAMP	1050	
	PIVOT BAR	1050	
	HINGE BLOCK	1050	

Appendix A **Relevant Knowledge of Mould Steel**

Mould steel is the most important technical and material basis of mould industry. In recent years, with the rapid development of mould industry, the development of mould steel is also very rapid. The output of mould steel is counted to alloy tool steel all over the world, which accounts for 70%-80% of the output of alloy tool steel. Five-Star Tooling is a manufacturer of injection mould design and manufacture. We use mould steel in a large number and widely. Therefore, this appendix would like to give a brief introduction to some relevant knowledge of mould steel.

A1. Classification of Mould Steel：

As the working conditions of various moulds vary greatly, the range of mould steel is very wide from general carbon structural steel, carbon tool steel, alloy tool steel, alloy structural steel and high-speed tool steel to non-magnetic die steel, corrosion resistant die steel and high alloy die materials that meet the requirements of special moulds, etc. This appendix classifies the following common mould steels:

- Plastic mould steel：

  The steel is relatively low in hardness, easy to cut, stable in scale, good in polishing and easy to process. It is mostly used in the internal mould of injection moulds. The injection moulding products produced can

have a certain gloss.

- Hot Work Steel：

  Hot-working steel has good elongation, low hardness, moderate resistance to heat softening, and can withstand high working temperature. It is mainly used in die casting mould, extrusion mould and plastic mould.

- Cold Work Steel：

  This kind of steel has good cutting property, high carbon content provides good wear resistance, but low toughness. It is mainly used to manufacture progressive pressing moulds, cold stamping moulds, cold drawing moulds, cold upsetting moulds, cold extrusion moulds, stamping moulds and rolling moulds under cold conditions (room temperature).

- High Speed Steel：

  This kind of steel is mainly used to cut other steel tool steel, can resist high temperature, wear resistance, high temperature is not easy to soften.

A2. Contrast table of common die steel in different countries:

There are many kinds and brands of mould steel. The following is a targeted comparison of several die steels commonly used in Five-Star Tooling:

Category	AISI	DIN	JIS	GB
PLASTIC MOULD STEELS	P20	1.2311	—	3Gr2Mo
	P20+Ni	1.2738	—	3Gr2Mo+Ni
	420	1.2083	SUS420J2	3Gr13
		1.2316	—	
HOT WORK STEELS	H10A	1.2885	SKD1	
	H13	1.2344	SKD61	4Gr5MoSiV1
	H19	1.2678	—	
	H21	1.2581	SKD5	
COLD WORK STEELS	O1	1.2510	SKS3	9GrWMn
	A2	—	—	
	D2	1.2379	SKD11	Gr12MoV
	D3	1.2080 1.2436	SKD1	Gr12
	D6	1.2436	—	
	SI	1.255	—	
HIGH SPEED STEELS	H10	—	SKD7	
	M2	1.3343	SKH51	
	M3.2	—	SKH53	
	M42	1.3247	SKH59	

A3. Thermal treatment of mould steel:

The materials used in injection, stamping or die casting moulds are likely to meet the performance requirements through some heat treatment methods, such as where friction, tension and impact often occur. Heat treatment is a way to change the mechanical properties of materials. Even if the composition of steel is the same, the properties of treated steel will be significantly different due to different heat treatment methods. This appendix introduces several common heat treatment and surface treatment methods:

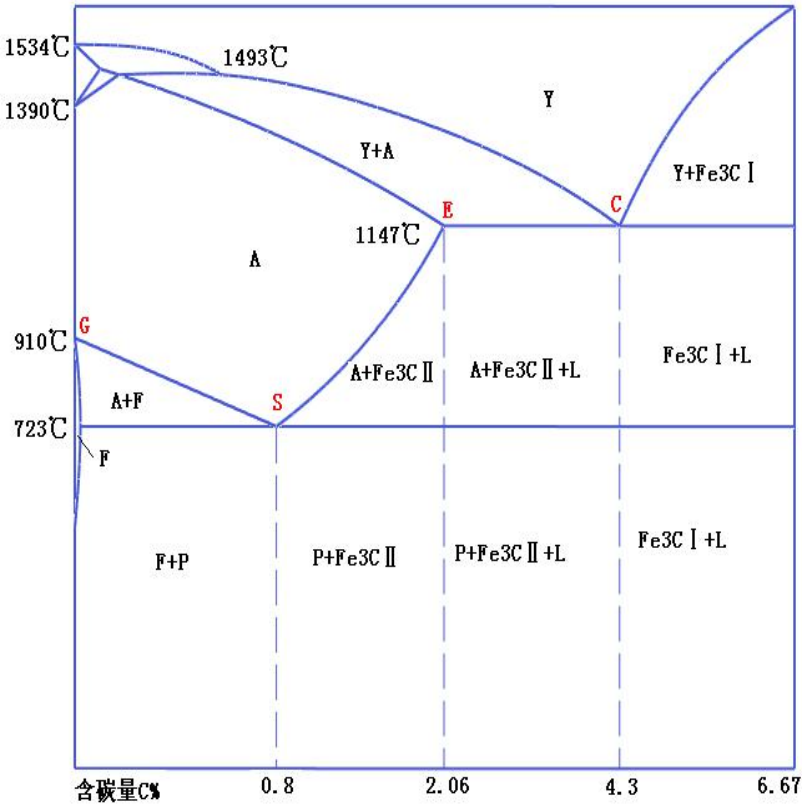

Figure 1: A sketch of iron-carbon balance

Remark：Acm： The AM line in the iron-carbon equilibrium diagram is 1147-723 C, 0.8 < C%< 2.06, and cementite begins to precipitate from austenite.

Ac3： In the iron-carbon equilibrium diagram, ferrite precipitates from austenite at 910-723 C%, C%<0.8.

Ac1： The eutectoid line in the iron-carbon equilibrium diagram is 723 C. The eutectoid mixture of ferrite and cementite begins to precipitate from austenite.

A3.1 Regular Heat Treatment：

Annealing (braising):

Definition	Heating the part to a temperature zone above or below Ac1 or Ac3, then cooling down slowly after heat preservation, to obtain pearlite structure by phase transformation, or to eliminate stress and reduce hardness without phase transformation.
Characteristic	The annealed structure has lower hardness and is easy to process. The annealing structure of phase transformation: hypoeutectoid → steel ferrite + pearlite. Hypereutectoid steel→ pearlite + secondary cementite.
Application	1. Reduce hardness, improve plasticity, improve cutting performance and pressure processing

	performance. 2. Fine grain size, adjust structure and improve mechanical properties to prepare for the next process. 3. Eliminate the internal stress produced by casting, forging, welding, rolling and cold working.
Other	Common annealing methods: complete annealing, diffusion annealing, incomplete annealing, isothermal annealing, spheroidizing annealing, stress relief annealing, crystallization annealing, etc.

Normalization (normalization or open fire):

Definition	Heat the part to Ac1 or Acm above 30~50 C for a certain period of time, then cool down at a slightly larger cooling rate than annealing, such as air cooling, air cooling, spray and so on, and obtain pearlite structure with smaller lamellar spacing.
Characteristic	Compared with annealing, pearlite has the advantages of fine structure, high dispersion, high mechanical properties, short production cycle, high equipment utilization rate and low cost, but poor working conditions.
Application	1. Used to eliminate the network cementite in hypereutectoid steel for spheroidizing annealing. 2. Normalizing is used to replace quenching treatment for some large heavy-duty steel parts with complex shapes and steels with sharp changes in cross-section, so that serious deformation or cracking occurs on the surface. 3. Normalizing is also suitable for medium carbon steels with carbon content ranging from 0.25% to 0.5%, such as 35 and 45 steels, but stress relief annealing is necessary for alloy steels with the same carbon content such as 5CrMnMo and 38CrMoAl after normalizing.
Other	

Quench:

Definition	A method of heat treatment in which the workpiece is heated to a temperature zone above the phase change temperature, kept warm for a certain time, and then cooled down rapidly.
Characteristic	Generally, the purpose is to obtain martensite with high hardness, but sometimes when quenching some high alloy steels, such as stainless steel and heat-resistant steel, it is to obtain a single homogeneous austenite structure to improve their corrosion resistance and wear resistance respectively.
Application	1. High hardness and wear resistance 2. Quenching and tempering at medium temperature to obtain good comprehensive mechanical properties. If the workpiece only needs local high hardness, local quenching can be carried out to avoid deformation and cracking in other parts of the workpiece.
Other	Common quenching methods include single liquid, double liquid, grading, isothermal quenching, etc.

Tempering:

Definition	The quenched workpiece is reheated to a certain temperature below Ac1 for a period of time, then taken out and cooled in a certain way.
Characteristic	After quenching, the structure of steel is martensite and part of retained austenite, which is in a metastable state, and tempering is the treatment to keep it in a stable state. With the decrease of tempering temperature, the plasticity and toughness increase.
Application	1. Reducing brittleness, eliminating internal stress and reducing deformation and cracking of workpiece 2. Adjust the hardness, improve the plasticity and toughness, and obtain the required mechanical properties of the workpiece. 3. Stable workpiece size
Other	Common tempering methods: low temperature tempering (150 ~ 250 C), medium temperature

	tempering (350 ~ 450 C), high temperature tempering and so on.

A3.2 Surface heat treatment：

Carburization：

Definition	The process of carburizing the surface of steel parts by putting the workpiece into carburizing medium and heating and holding at 900-950_C.
Characteristic	The final structure of the part is acicular tempered martensite and secondary cementite with hardness HRC58-65. The core structure is low carbon martensite, troostite and sorbite with different steel grades. The hardness is between HRC25-45. It has high flexural fatigue resistance, surface wear resistance or impact resistance of the core. They are higher than those of medium carbon steel after surface hardening.
Application	The purpose of carburizing is to improve the hardness and wear resistance of steel surface, while the core retains toughness and high plasticity; too thin carburizing layer can easily cause surface fatigue spalling, too thick can not withstand impact; Parts requiring high wear resistance can be approximately referred to in the following table according to load conditions:
Other	When carburized parts are not allowed to have high hardness, the method of copper plating can be adopted to carburize or the method of excessive machining allowance can be adopted.

Load	Low	More	Heavy	Overweight
Carburized layer mm	<0.5	0.5～1.0	1.0～1.5	>1.5

Nitridation：

Definition	Nitrogen is a chemical heat treatment method to infiltrate the surface layer of steel parts. Usually, ammonia (NH3) is introduced into the furnace at about 550 C. Nitrogen obtained by decomposition of ammonia is infiltrated into steel.
Characteristic	Nitriding takes a long time. The nitriding layer has the characteristics of high hardness HV850-HV1200, high wear resistance, anti-occlusion, corrosion resistance and high fatigue. Fe2N nitride phase is easily formed in the outermost layer of gas nitriding, which makes the nitriding layer brittle.
Application	Alloy steels containing Al, Cr and Mo are usually nitrided to form highly dispersed alloy nitrides on the surface of nitrided layer, which further strengthens the nitrided layer.
Other	

Ionic Nitriding：

Definition	The glow discharge phenomena of nitrogen-containing gases are used. The positive ions of nitrogen and hydrogen produced by gas ionization move towards the parts under electric field and impact the parts surface at a great speed. Nitrogen is adsorbed by the parts and diffuses inward to form nitriding layer.
Characteristic	Compared with general nitriding: Advantage: 1. Short production cycle, 1/2-1/5 of gas nitriding; 2. Nitride layer has good quality and low brittleness. 3. Small deformation, no abrasion or less abrasion; 4. Local nitriding can be realized by mechanical shielding, and tin or nickel plating can be omitted.

	5. Stainless steel and heat-resistant steel do not need to remove passivation film beforehand, which can save sand blasting, pickling and other processes. 6. Power saving, ammonia saving and good operation conditions; Disadvantage: It is difficult to achieve the same hardness and depth when parts are complex or cross-sectional.
Application	Basically applicable to all steel materials. However, the surface hardness of alloy steel containing Al, Cr, Ti, Mo, V alloying elements after ion nitriding is higher than that of carbon steel after ion nitriding. It is mostly used for precision parts, as well as parts requiring wear resistance which can not be achieved by other treatment methods such as stainless steel.
Other	

Soft Nitriding (Nitrocarburizing)：

Definition	The nitrocarburizing process of the workpiece in a salt bath containing 36% CNO is maintained at about 570 C for 90-120 min.
Characteristic	In addition to some of the above-mentioned good properties, because the surface does not form brittle Fe2N, mainly into Fe3N, its brittleness and crack sensitivity are small. The depth of the chemical layer is about 0.005-0.01mm, and the depth of the diffusion layer is 0.2-0.5mm. The wear resistance of the co-penetrating layer is higher and the deformation of the workpiece is minimal. Production cycle is shorter than nitriding.
Application	Carbon steel, alloy steel, tool steel, stainless steel, cast iron, powder metallurgy materials can be soft nitrided. Parts requiring wear resistance, plastic hot working dies, etc. after soft nitriding, their service life can be significantly improved (1 to several times).
Other	

A3.3 Surface coating treatment：

Chromium plating：

Definition	The process of depositing metal chromium on the surface of workpiece by electrolysis to form a uniform, compact and well-bonded metal chromium coating.
Characteristic	Chromium layer has strong adhesion, high hardness, HV800-1000, good wear resistance, strong light reflection and high heat resistance. Its shortcomings are hard, brittle and easy to fall off. It is more obvious when subjected to alternating impact load. It is porous. Generally, the purpose of anti-rust and decoration is achieved by multi-layer electroplating (i.e. copper, nickel and chromium plating).
Application	It is widely used in improving wear resistance, repairing dimension, light reflection and decoration of parts. The thickness of chromium plating in repair dimension should be determined according to the wear degree, and it should be grinded after chromium plating to a certain thickness.
Other	

Nickel-plating ：

Definition	The process of depositing nickel on the workpiece surface by electrolysis to form a nickel metal coating.
Characteristic	Nickel has good chemical stability in atmosphere and alkali solution, and is not easy to discolor. It is oxidized only when the temperature is above 600 C. It dissolves slowly in sulfuric acid and hydrochloric acid, but easily in dilute nitric acid. It is easy to passivate in concentrated nitric acid, so it has good corrosion resistance. Nickel coating has high hardness, easy polishing, high light reflectivity and beautiful appearance. In order to overcome this shortcoming, multi-layer metal coating can be used, while nickel is the intermediate layer.

Application	Usually in order to prevent corrosion and increase aesthetic use, it is generally used to protect decorative coatings. Nickel plating on copper products is ideal for corrosion protection, but because nickel is more valuable, copper-tin alloy is often used instead of nickel plating.
Other	

A3.4 Surface heat treatment data of some steels (mainly refer to ASSAB product information)

Steel Type	Surface heat treatment	Temp(℃)	Holding time（h）	Depth(mm)	HV
P20	Gas nitriding	528	20	0.30	650(HRC57.8)
			30	0.35	
			6	0.50	
	Soft Nitriding	570	2	0.10	700(HRC60)
H13	Gas nitriding	525	10	0.125	1000-1250 (HRC70 以上)
			20	0.180	
			40	0.250	
			60	0.300	
	Soft Nitriding	570	2	0.10	950-1000(HRC66 以上)
420	Soft Nitriding (Processi not recommended)	560	2	0.8-0.10	900 (HRC66)
8407 (AISI ： H-13)	Nitridation	525	20	0.20	1000-1250
			30	0.25	
			60	0.30	
	Soft Nitriding	570	2	0.1～0.2	950-1000
XW-42 (AISI： D2)	Nitridation	525	20	0.25	1250
			30	0.30	
			60	0.35	
	Soft Nitriding	570	2	0.1～0.2	950

A3.5 Marking Requirements for Heat Treatment Drawings of Parts：

Heat Treatment	Requirements for heat treatment in part drawings
1.General heat treatment	Heat treatment method and hardness (when labeled, the fluctuation range of HRC is about 5 units and HB is about 30-40 units)
2.Carburization	Heat treatment method, hardness and depth of carburized layer
3.Nitriding	Heat treatment method, surface and core hardness, nitriding depth, nitriding area
4. Soft nitriding (carbonitriding)	Heat treatment method, surface and core hardness, nitriding depth, nitriding area