An Overview of Equipment Designs for the Heat Treatment of Fasteners

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The heat treatment of fasteners can be done in a variety of industrial furnaces and ovens, which are available in a myriad of shapes and sizes. Some are designed to run a wide range of diverse products; others dedicated to running one particular component part. Similarly, the processes run in them can also be quite diverse, ranging from annealing to hardening to tempering; some furnaces must have the flexibility to run almost anything; others are focused on a single process application. Some of the more common types and the applications for the heat treatment of fasteners will be discussed here.

Heat treatment systems for fasteners must all have one thing in common – flexibility; the capability to produce large or small quantities of fasteners "on demand". It is not uncommon to see production lots as small as 4.5 kg (10 lbs.) and as large as 4535 kg (10,000 lbs.) or more. The most common heat treatments for fasteners involve hardening and case hardening (carbonitriding and carburizing) followed by tempering. Case depths are shallow, typically 0.0038 – 0.038 mm (0.0015" to 0.015"). Quench media runs the gambit from brine, water, polymer, oil, and molten salt depending on engineering requirements.

The characteristics of various types of furnaces and ovens are outlined below so as to provide general guidelines for their use. Normal operating temperatures (**Table 1**), common applications performed in each type of furnace (**Table 2**) and the type of atmosphere run (**Table 3**) are examples of the information needed to help determine if a particular furnace style is appropriate for a given product.

Table 1[1] Typical Furnace Operating Temperature Ranges 表1[1]、热处理炉典型操作温度范围

Furnace Style 炉体样式	Typical Operating Range , °C (°F) 典型操作范围, °C (°F)
Box 箱式	205 – 1175 (400 – 2150)
Pit 坑式	120 – 1090 (250 – 2000)
Mechanized Box (Integral Quench) 机械化箱式（整体淬火）	760 – 980 (1400 – 1800)
Bell 钟罩式	400 – 1040 (750 – 1900)
Salt Bath 盐浴式	205 – 1315 (400 – 2400)
Gantry 活顶门式	790 – 980 (1400 – 1800)
Tip-Up 端部翻起式	595 – 980 (1100 – 1800)
Carbottom 台车车底式	425 – 1205 (800 – 2200)
Mesh Belt Conveyor Furnace (with or without support rollers, open chamber of muffle style) 网带输送式（有或无支撑滚轮，马弗隔焰开放炉膛）	205 – 1175 (400 – 2150)
Mesh Belt Conveyor Furnace (Ceramic Belt) 网带输送式（陶瓷皮带）	205 – 1315 (400 – 2400)
Inclined (Humpback) Conveyor Furnace 前倾（隆起）输送式	540 – 1175 (1000 – 2150)
Cast Link Conveyor Furnace 铸铁链接输送式	540 – 955 (1000 – 1750)
Roller Hearth Furnace 滚轮底式	425 – 1010 (800 – 1850)
Pusher Furnace 推进杆式	845 – 1010 (1550 – 1850)
Walking Beam 步进梁式	955 – 1290 (1750 – 2350)
Rotary Drum 旋转桶槽式	790 – 955 (1450 – 1750)
Rotary Hearth 转底式	790 – 925 (1450 – 1700)
Shaker Hearth Furnace 振底式	845 – 1010 (1550 – 1850)
Monorail 单轨式	790 – 955 (1450 – 1750)
Tube Annealing Furnace 管式退火	760 - 1150 (1400 – 2100)
Screw Conveyor 螺旋输送式	675 – 955 (1250 – 1750)
Chain Conveyor 炼式输送带	675 – 955 (1250 – 1750)
Forge Furnace 锻造式	870 – 1315 (1600 – 2400)

紧固件热处理设备设计概观

紧固件热处理所使用的加热及处理炉，其形状和大小种类繁多。有些为多样产品广泛应用而设计，其他则专为某种特定零组件而开发。同样的，热处理炉内操作的处理种类也相当多，从退火、硬化到回火；有些炉体具有高度的灵活度，能够操作各种热处理加工制程，其他则专门应用于单一处理。本文将讨论紧固件热处理较为常见的类型及其应用。

所有紧固件热处理系统必定都有一个共同点—「灵活度」，即是「因应需求」加工产出大批量或小批量的紧固件。小批量如4.5公斤(10磅)，大批量如4,535公斤(10,000磅)或更大批量的生产并非罕见。最常见的紧固件热处理制程涉及硬化和表面硬化(碳氮共渗和渗碳)，之后就是回火。表面硬化层的深度很浅，通常是0.0038~0.038毫米(0.0015 "~0.015")。淬火介质视工程要求而定，可以是盐水、水、聚合物、油，以及熔融盐类。

以下概略叙述不同类型处理炉特性，以便提供一般性的使用原则。正常的操作温度(**表1**)，各类型热处理炉常见的应用(**表2**)以及炉体内运作气氛(**表3**)，诸如此类的资讯都有助于决定某种炉体型式是否适合指定产品所需。

注意事项：

a. 最常见的炉内气氛为空气。对于某些如回火的低温操作来说，材料表面的最终条件必须能够容忍轻微程度的氧化。铝合金的固溶热处理和老化操作是另一个例子，其中紧密附着已经存在的氧化层让处理可在空气中进行。

b. 氩气和氮气是真实的惰性气体。在一定条件下，氮气可能导致表面产生化学反应，例如在980°C(1,800°F)以上的温度加工不锈钢可能导致表面累积氮气。氢气具高度还原性，在某些特定合金(例如钛、钽)可能导致氢脆化。

Table 2[1]Common Applications of Heat Treating Furnaces 表2[1]、热处理炉常见应用

Furnace Style 炉体样式	Application Use 应用
Bell 钟罩式	Aging, Bluing, Hardening, Nitriding, Solution Heat Treatment, Stress Relieving, Tempering 老化，烧蓝，硬化，渗氮，固溶处理，消除应力，回火
Box 箱式	Aging, Annealing, Carburizing, Hardening, Malleabilizing, Normalizing, Solution Heat Treatment, Stress Relieving, Tempering 老化，退火，渗碳，硬化，锻铸冶金化，正火，固溶处理，消除应力，回火
Car Bottom 台车车底式	Annealing, Carburizing, Hardening, Homogenizing, Malleabilizing, Normalizing, Spheroidizing, Stress Relieving, Tempering 退火，渗碳，硬化，均质，锻铸冶金化，正火，球化，消除应力，回火
Cloverleaf 三叶草式	Annealing, Carbon Restoration, Carbonitriding, Carburizing, Hardening, Normalizing, Tempering 退火，碳修复，碳氮共渗，渗碳，硬化，正火，回火
Continuous Slab 连续板式	Carburizing, Homogenizing, Solution Heat Treatment 渗碳，均质化，固溶热处理
Conveyor 输送式	Austempering, Annealing, Brazing, Carbon Restoration, Carbonitriding, Carburizing, Hardening, Homogenizing, Spheroidizing, Tempering 等温淬火，退火，焊焊，碳修复，碳氮共渗，渗碳，硬化，均质，球化，回火
Electron Beam 电子束冲击式	Hardening (surface) 硬化(表面)
Elevator Hearth 炉室升高式	Aging, Annealing, Hardening, Malleabilizing, Solution Heat Treatment, Stress Relieving, Tempering 老化，退火，淬火，可锻铸冶金化，固溶处理，消除应力，回火
Fluidized Bed 流化床式	Carbonitriding, Carburizing, Hardening, Nitriding, Nitrocarburizing, Steam Treating, Tempering 碳氮共渗，渗碳，硬化，渗氮，氮碳共渗，蒸汽处理，回火
Humpback 前倾(隆起背)输送式	Annealing, Brazing, Hardening, Stress Relieving, Sintering 退火，焊焊，硬化，应力消除，烧结
Induction 感应式	Hardening, Tempering 硬化，回火
Integral Quench 整体淬火式	Austenitizing, Annealing, Carbon Restoration, Carbonitriding, Carburizing, Hardening, Nitrocarburizing, Normalizing, Stress Relieving, Tempering 奥氏体化，退火，碳修复，碳氮共渗，渗碳，淬火，氮碳共渗，正火，消除应力，回火
Ion 离子式	Carbonitriding, Carburizing, Nitriding, Nitrocarburizing 碳氮共渗，渗碳，渗氮，氮碳共渗
Laser 激光式	Annealing 退火
Monorail 单轨式	Annealing, Hardening, Normalizing, Stress Relieving, Tempering 退火，退火，正火，消除应力，回火
Pit 坑式	Annealing, Bluing, Carbon Restoration, Carbonitriding, Carburizing, Hardening, Homogenizing, Nitrocarburizing, Nitriding, Normalizing, Solution Heat Treatment, Steam Treating, Stress Relieving, Tempering 退火，发蓝，碳修复，碳氮共渗，渗碳，硬化，均质，氮碳共渗，渗氮，正火，固溶热处理，蒸汽处理，消除应力，回火
Pusher 推进杆式	Annealing, Carbon Restoration, Carbonitriding, Carburizing, Hardening, Malleabilizing, Metallizing, Nitrocarburizing, Normalizing, Solution Heat Treatment, Sintering, Spheroidizing, Stress Relieving, Tempering 退火，碳修复，碳氮共渗，渗碳，淬火，锻铸冶金化，金属化，氮碳共渗，正火，固溶热处理，烧结，球化退火，消除应力，回火
Quartz Tube 石英管式	Hardening, Sintering 硬化，烧结
Resistance Heating 电阻加热式	Aging, Annealing, Carbonitriding, Hardening, Normalizing, Stress Relieving 老化，退火，碳氮共渗，硬化，正火，应力消除
Roller Hearth 滚轮底式	Bluing, Carbon Restoration, Carbonitriding, Carburizing, Hardening, Malleabilizing, Normalizing, Solution Heat Treatment, Spheroidizing, Stress Relieving, Tempering 烧蓝，碳修复，碳氮共渗，渗碳，硬化，锻铸冶金化，正火，固溶热处理，球化，消除应力，回火
Rotating Finger 指状旋转式	Annealing, Hardening, Normalizing, Stress Relieving, Tempering 退火，硬化，正火，消除应力，回火
Rotary Hearth 转底式	Annealing, Austempering, Carbon Restoration, Carbonitriding, Carburizing, Hardening, Tempering 退火，等温淬火，碳修复，碳氮共渗，渗碳，硬化，回火
Salt Bath 盐浴式	Austempering, Carbonitriding, Carburizing, Hardening, Malleabilizing, Martempering, Nitrocarburizing, Normalizing, Tempering 等温淬火，碳氮共渗，渗碳，硬化，锻铸冶金化，分级淬火，氮碳共渗，正火，回火
Screw Conveyor 螺旋输送式	Annealing, Hardening, Stress Relieving, Tempering 退火，硬化，消除应力，回火
Shaker Hearth 振底式炉	Annealing, Carbonitriding, Carburizing, Hardening, Normalizing, Stress Relieving, Tempering 退火，碳氮共渗，渗碳，硬化，正火，消除应力，回火
Split 分叉式	Annealing, Stress Relieving 退火，应力消除
Tip-Up 端部翻起式	Annealing, Hardening, Malleabilizing, Normalizing, Spheroidizing, Stress Relieving, Tempering 退火，硬化，锻铸冶金化，正火，球化，消除应力，回火
Vacuum 真空式	Annealing, Brazing, Carbon Deposition, Carbonitriding, Carburizing, Degassing, Hardening, Nitrocarburizing, Normalizing, Solution Heat Treatment, Sintering, Stress Relieving, Tempering 退火，焊焊，积碳，碳氮共渗，渗碳，脱气，淬火，氮碳共渗，正火，固溶热处理，烧结，消除应力，回火
Walking Beam 步进梁式	Annealing, Hardening, Normalizing, Sintering, Stress Relieving, Tempering 退火，硬化，正火，烧结，消除应力，回火

Table 3[1] Common Types of Furnace Atmospheres 表3[1]、炉体气氛常见类型

Type 类型	Chemical Symbol 化学符号	Remarks 备注
Air [a] 空气[a]	$N_2 + O_2$	Air is approximately 79% nitrogen, 20.5% oxygen. 空气约是79%的氮气，20.5%的氧气
Argon [b] 氩[b]	Ar	Argon is an inert gas. 氩是一种惰性气体
Alcohols 醇	C_6H_6, C_7H_8	Atmosphere created by the decomposition of benzene or toluene dripped into a hot furnace. 炉内气氛以滴入分解的苯或甲苯的方式制造。
Blended Atmospheres 混合气体		Mixtures of various gases including nitrogen (0 - 100%) and hydrogen (0 - 100%) blends, and so-called "wet" atmospheres, that is high dew point nitrogen or hydrogen mixed with dry gas. 各种气体的混合物，包括氮气(0 - 100%)和氢气(0 - 100%)的共混物，以及所谓的"湿"的气氛，也就是与干燥气体混合的高露点氮气或氢气。
Carbon Dioxide 二氧化碳	CO_2	
Carbon Monoxide 一氧化碳	CO	
Custom Blends 客制混合气体		Alcohols, Combinations of N2 + Other Gases. 醇，以及N2+其他气体的组合
Generated Atmospheres [d] 制造生成气氛[d]		Endothermic, Exothermic, Dissociated Ammonia. 吸热，放热，分解的氨
Helium [b] 氦[b]	He	Helium is considered an inert gas. 氦被认为是一种惰性气体
Hydrocarbons 碳氢化合物	CH_4, $C3H_8$, C_4H_{10}	Typically Methane (CH4), Propane (C3H8), Butane C4H10). 典型来说，甲烷(CH 4)、丙烷(C 3 H 8)、丁烷(C 4 H 10)
Hydrogen [b] 氢[b]	H_2	
Nitrogen [b] 氮[b]	N_2	
Oxygen 氧气	O_2	
Products of combustion [c] 燃烧产品[c]		A mixture of a hydrocarbon fuel gas and air whose composition is dependent on the air/gas ratio. 碳氢化合燃气和空气的组合物，其成份由空气/燃气比例决定
Steam 蒸汽	H_20	Promotes a stable oxide layer on the part surface. 促进零部件表面氧化层的稳定
Sulfur Dioxide 二氧化硫	SO_2	Used for processing magnesium alloys. 用于镁合金的加工
Synthetic Atmospheres [e] 合成的气氛[e]		Nitrogen/Methanol. 氮/甲醇
Vacuum [f] 真空[f]		Vacuum is the absence of an atmosphere. 真空不存在任何气氛

Notes:

The most common furnace atmosphere is air. For certain low temperature operations such as tempering, the final condition of the material's surface must be able to tolerate a slight degree of oxidation. Solution heat treatment and aging operations on aluminum alloys is another example where the tightly adherent oxide layer already present allows for processing in air.

Argon and helium are true inert gases. Nitrogen may be reactive to the surface under certain conditions (e.g. processing of stainless steels above 980 °C (1800 °F) can result in nitrogen pickup on the surface). Hydrogen is highly reducing but can lead to embrittlement in certain alloys (e.g., titanium, tantalum).

The products of combustion are often utilized as a furnace atmosphere for box style furnaces, carbottom furnaces, tip-up furnaces and many other designs. Depending on the resultant composition and the tolerance of the steel to surface oxidation, this atmosphere is often sufficient. Fasteners are typically not heat treated in this type of atmosphere.

Generated atmospheres produce combinations of gases of specific composition and are prepared on site by use of gas generators that are designed for this purpose. The "feed" stock (i.e., the hydrocarbon fuel gas) in combination with air creates the atmosphere. The feedstock is typically natural gas, propane or butane. Endothermic

c. 箱式炉，台车车底式炉，端部翻起式炉和许多其它设计常常将燃烧产物作为炉体气氛。根据产出物组成以及钢材表面氧化的公差，这种类型的气氛通常足够用来做热处理。但是紧固件通常不以这种类型的气氛做热处理。

d. 制造生成的气氛是特定成份气体的组合，因此可利用气体产生机依所需气氛在现场制备。这些"进料"材料(即碳氢化合燃气)加上空气，共同制作出气氛。该原料通常是天然气，丙烷或丁烷。吸热气体是紧固件硬化和表面硬化最常使用的炉气氛。

e. 合成气氛是那些由氮气和醇组合制备的气氛。若有某些预防措施，这种气氛可用于紧固件热处理(例如避免表面脱碳)

f. 真空可以被认为是不存在有气氛。真空热处理和所有其他形式的热处理之间一个主要的差别是不存在有表面反应，或者对表面反应不加以精确的控制。在许多情况，热处理工序一开始就进行真空化，以确保在引入另一种气氛之前，先行清除炉内环境的氧气。放置在炉内的蒸馏器通常利用这种作法。真空炉经常在部份压力下进行热处理工序。氩、氢和氮是最常见的部份压力气体，因此选择这些气体要特别留意，务必考虑到安全性，对于处理中所用物质的反应性，最后才是成本。许多材料在真空操作处理的工作温度和压力状况下，其自身元素可能挥发，也就是说，自部件表面离开。部份压力系统的设计即是在防止这种情况发生，借由整合考量「压力-温度-时间」，将易于挥发的合金物质的挥发程度减少到最低。

在操作过程中，某些热处理炉的保护性气氛安全使用量，在很大程度上取决于：

- 炉体的类型和大小；
- 是否设有门和(或)遮帘；
- 环境(尤其是风的输送)；
- 大小、荷载、朝向，以及加工处理的性质；
- 所牵涉的冶金工艺。

在所有的情况下，炉体制造商的建议必须遵循，因为他们在设计这些设备时都已考量这些因素。记住，引入可燃炉内气氛之前，自炉内清除空气准备引入气氛的时候，炉室中含氧量必须降低到1%以下。这相当于至少数值为(5.0)的(表4)炉体气氛体积变化百分比。

gas is one of the most common furnace atmospheres for the hardening and case hardening of fasteners.

Synthetic atmospheres are those produced from combinations of nitrogen and alcohols. This atmosphere can be used for fastener heat treatment with certain precautions (e.g., avoidance of surface decarburization)

Vacuum can be thought of as the absence of an atmosphere. A principal difference between vacuum heat-treating and all other forms of heat treatment is the absence of, or the precise control over, surface reactions. In many instances a vacuum purge is utilized at the onset of a heat treatment process and designed to ensure the removal of oxygen from the furnace environment prior to introduction of another type of atmosphere. Retorts placed inside furnaces often utilize this practice. Vacuum furnaces often perform their heat treatment processes under partial pressure. Argon, hydrogen, and nitrogen are the most common partial pressure gases and their selection must be carefully made taking into account safety, reactivity with the materials being processed and cost. Many of the materials run in vacuum are processed at temperatures and pressures at which individual elements can volatilize, that is, leave the part surface. Partial pressure systems are designed to prevent this from happening by establishing a combination of pressure-temperature-time that minimizes the vaporization of the more volatile alloy constituents.

During operation, the volume of protective atmosphere required for safe use in a particular heat-treating furnace depends to a great extent on the:

- Type and size of furnace;
- Presence or absence of doors and/or curtains;
- Environment (especially drafts);
- Size, loading, orientation, and nature of the work being processed;
- Metallurgical process involved.

In all cases, the manufacturer's recommendations should be followed since they have taken these factors into account during the design of the equipment. Remember that to purge air out of a furnace prior to introduction of a combustible furnace atmosphere requires achieving an oxygen content in the chamber of below 1% prior to the introduction of the atmosphere. This corresponds to a minimum of five (5) volume changes of the chamber (**Table 4**).

Table 4[1] Effect of Volume Changes on Percent Initial Gas or Mixture Remaining
表4[1]、量变对于初始气体或剩余混合气体百分比的影响

No. of Volume Changes 量变	% of Initial Gas Remaining in Vessel 容器中剩余的初始气体(%)
0.1	90.48
0.2	81.87
0.3	74.08
0.5	60.65
1.0	36.79
2.0	13.53
3.0	4.98
4.0	1.83
5.0	0.67

Furnace Styles

In broad based terms, furnaces and ovens can be divided into three basic types: batch, continuous and special purpose (**Table 5**). Batch units tend to process large workloads running for long periods of time. In a batch unit the work charge is typically stationary so that interaction with the furnace atmosphere is often considered to be in near equilibrium conditions. By contrast, the movement of the workload in some manner during processing characterizes continuous furnaces and the atmosphere surrounding the workload can change dramatically as a function of the position of the work charge.

Table 5 Types of Batch and Continuous Furnaces and Ovens
表5、批次式和连续式加热炉的类型

Furnace Style [a] 炉体样式 [a]		
BATCH 批次式	CONTINUOUS 连续式	SPECIAL PURPOSE 特殊用途
Box (Fig. 1) 箱式 (图1)	**Mesh belt conveyor (Fig. 3) 网式输送带 (图3)**	Tube 管线
Pit 坑式	Inclined humpback conveyor 前倾隆起式输送带	Screw conveyor 螺旋式输送带
Integral quench (Fig. 2) 整体淬火式 (图2)	**Cast link belt (Fig. 4) 铸铁链接输送带 (图4)**	Chain conveyor 链条输送带
Bell furnaces 钟罩式	**Roller hearth (Fig. 5) 滚轮底炉 (图5)**	Slab and billet heating; 板坯和方坯加热
Elevator hearth 升高底炉	Pusher 推进杆	Forge 锻造
Gantry 活顶门式	Walking beam 推进杆	Kilns 锻造
Salt bath 盐浴式	**Rotary drum (Fig. 6) 旋转桶槽 (图6)**	Split (wrap around) 分叉(环绕)
Tip-Up 端部翻起式	Rotary (Ring) hearth 旋转（环式）底炉	Deep freeze (cryogenic) 深度冷凝(低温)
Carbottom 台车车底式	**Shaker hearth (Fig. 7) 振底式炉 (图7)**	Dip tanks 浸渍槽
Horizontal vacuum (Fig. 8) 水平式真空炉 (图8)	Monorail 单轨式	

Notes:
The designs most appropriate for fastener heat treatment are shown in bold print.

注意事项：[a]最适合紧固件热处理的设计以粗体字显示。

炉体样式

在广泛的基础上，热处理炉可以分为三种基本类型：批次式、连续式、特殊用途式(**表5**)。批次式处理单元通常工作件数量大，操作时间长。批次处理的工件一般而言是静止不动，炉内气氛交相作用通常可以说是几近平衡状态。对照之下，连续式的特征是工作件在处理加工过程中以某种方式的移动，并且工作件周围的气氛可能因应工作件增加而有钜大的改变。

(a) (b)

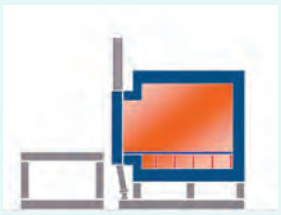

Figure 1 Box Style Furnace
(a) Typical Furnace Installation
(Photograph Courtesy of JL Becker, a Gasbarre Furnace Group Company)
(b) Cross Sectional View (Photograph Courtesy of SECO/WARWICK Corporation)
图1 箱式炉
(a)典型炉体安装(JL Becker 烧结炉公司提供) (b)剖面图 (SECO/Warwick 公司提供)

(a) (b)

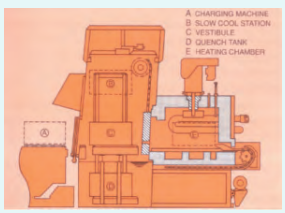

Figure 2 Mechanized Box (Integral Quench) Style Furnace
(a) Typical Furnace Installation
(Photograph Courtesy of JL Becker, a Gasbarre Furnace Group Company)
(b) Cross Sectional View (Photograph Courtesy of ASM International)
图2 机械化箱式(整体淬火)炉
(a)典型炉体安装 (JL Becker 烧结炉公司提供) (b)剖面图 (ASM国际公司提供)

(a) (b)

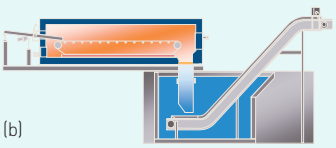

Figure 3 Mesh Belt Conveyor Furnace
(a) Typical Furnace Installation (Photograph Courtesy of Williams Industrial Service, Inc.)
(b) Cross Sectional View – Furnace & Quench Tank
(Photograph Courtesy of SECO/WARWICK Corporation)
图3 网带输送式炉
(a)炉体安装典型 (Williams Industrial Service 公司提供)
(b)剖面图 - 热处理炉及淬火槽 (SECO/Warwick 公司提供)

(a) (b)

Figure 4 Cast Link Belt Furnace
(a) Typical Furnace Installation (Photograph Courtesy of Surface Combustion, Inc.)
(b) Cross Sectional View – Quench End
图4 铸铁链接输送式炉
(a)典型炉体安装 (Surface Combustion, Inc. 公司提供) (b)剖面图 - 淬火端

(a) (b)

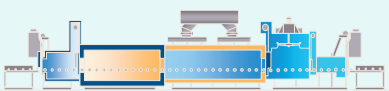

Figure 5 Roller Hearth Furnace
(a) Typical Furnace Installation (Photograph Courtesy of SECO/WARWICK Corporation)
(b) Cross Sectional View (Photograph Courtesy of SECO/WARWICK Corporation)
图5 滚轮底炉
(a)典型炉体安装 (SECO/Warwick 公司提供) (b)剖面图 (SECO/Warwick 公司提供)

(a) (b)

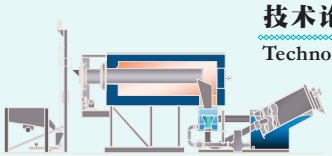

Figure 6 Rotary Drum Furnace
(a) Typical Furnace Installation (Photograph Courtesy of SECO/WARWICK Corporation)
(b) Cross Sectional View (Photograph Courtesy of SECO/WARWICK Corporation)
图6 旋转桶槽炉
(a)典型炉体安装 (SECO/Warwick 公司提供) (b)剖面图 (SECO/Warwick 公司提供)

(a) (b)

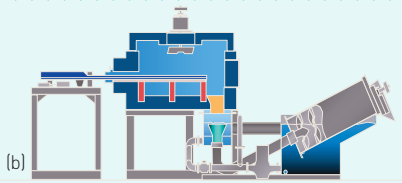

Figure 7 Shaker Hearth Furnace
(a) Typical Furnace Installation (Photograph Courtesy of DF Industries)
(b) Cross Sectional View (Photograph Courtesy of SECO/WARWICK Corporation)
图7 振式底炉
(a)典型炉体安装 (DF Industries 公司提供) (b)剖面图 (SECO/Warwick 公司提供)

(a) (b)

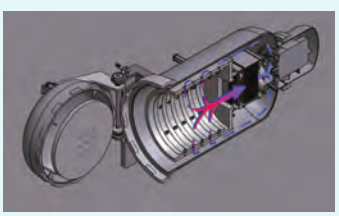

Figure 8 Horizontal Vacuum Furnace
(a) Typical Furnace Installation (Photograph Courtesy of Solar Atmospheres Inc.)
(b) Cross Sectional View (Photograph Courtesy of Solar Atmospheres Inc.)
图8 水平式真空炉
(a)典型炉体安装 (Solar Atmosphere Inc. 公司提供)
(b)剖面图 (Solar Atmosphere Inc. 公司提供)

Final Thoughts

The proper selection of heat treatment equipment must be done in conjunction with the original equipment manufacturer. For his part, the purchaser must have a clear understanding of his application requirements, productivity needs and the capabilities and limitations of his personnel in addition to many other considerations. The OEM supplier must be able to provide guidance and offer solutions to meet the needs presented.

结语

选用适当的热处理设备必须由采购与原始设备制造商买卖双方共同进行。就公司的采购人员而言，必须清楚了解公司的应用需求、产能需求、操作人员的能力和限制，以及许多其他的因素。至于作为OEM供应商的卖方，必须能够提供指导，并提供解决方案，以满足买方所提出的需求。

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