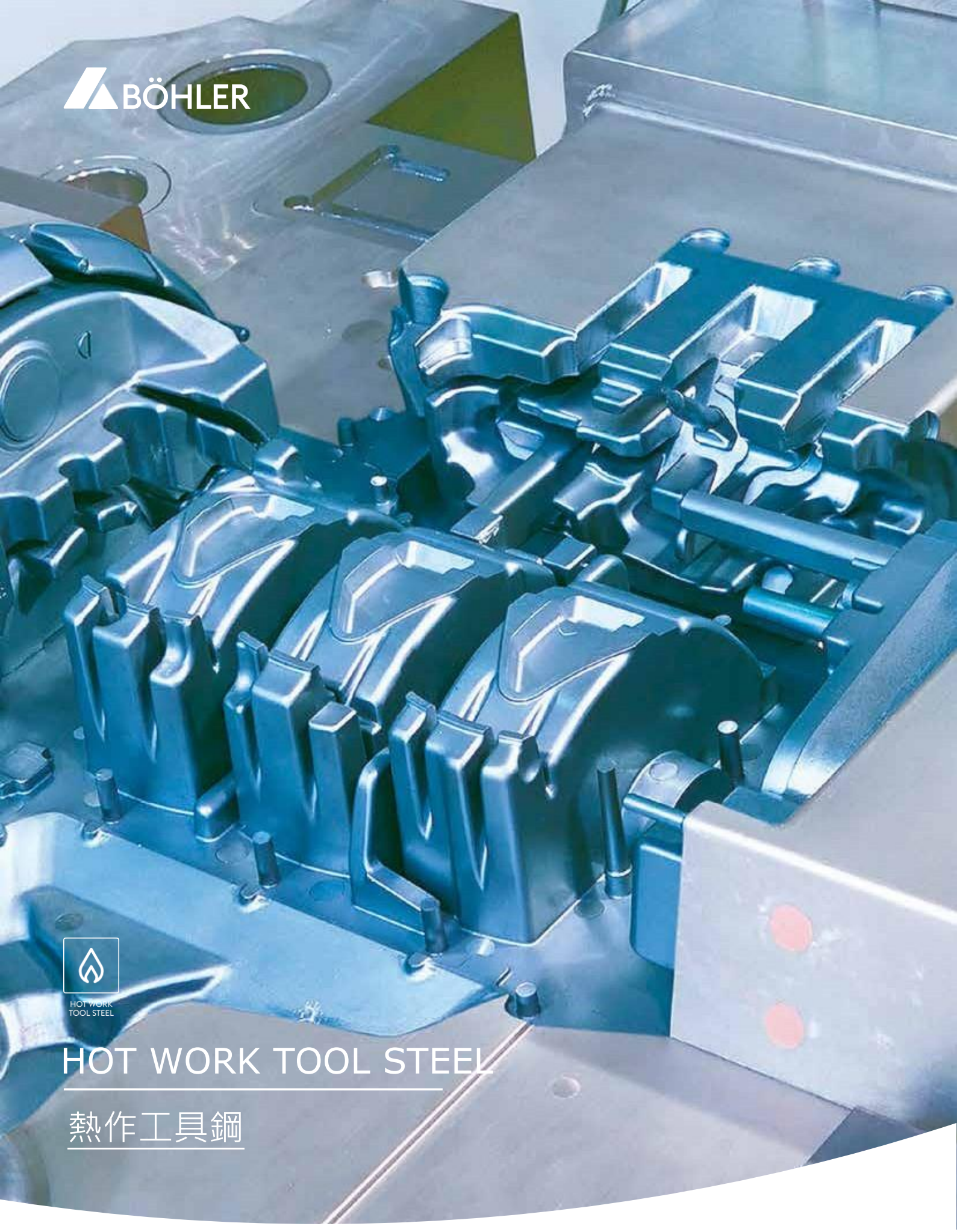


BÖHLER

HOT WORK
TOOL STEEL

HOT WORK TOOL STEEL

熱作工具鋼

voestalpine BÖHLER Edelstahl GmbH & Co KG
www.voestalpine.com/bohler-edelstahl

voestalpine
ONE STEP AHEAD.

WU JII
梧濟五業股份有限公司
WU JII INDUSTRY CO., LTD.

高熱負載之應用

FOR THE HIGHEST THERMAL LOAD

As the leading producer of tool steel worldwide voestalpine BÖHLER is focused on solving the most demanding customer problems when it comes to toolmaking. One of our top priorities here is hot work tool steels.

Hot work tool steels are alloyed tool steels for use in applications in which the surface temperature is generally above 200 °C. During the application the tool briefly comes into contact with hot material, the temperatures of which are well above 200 °C. Besides long term thermal load, there is the additional stress due to periodic change of temperature.

Tool steels for such applications have to be able to stand up to not only the universal mechanical and abrasive stress generally occurring in tool steels, they have to stand up to thermal load as well.

奧鋼聯百樂鋼廠作為世界領先工具鋼製造者，致力於替客戶解決工具製造中所遭遇最嚴苛的問題，首要任務之一就是進而提供最符合業界需求的熱作工具鋼。

熱作工具鋼通常應用於表面溫度高於200°C之環境的合金工具鋼。在此工具鋼使用過程中，表面會短暫接觸溫度高於200°C的熱料，由於溫度會有冷熱交替變化，在如此長期熱負載模式下，會承受到額外之應力。

在此類型應用之工具鋼，必須能夠承受常態機械應力和磨擦應力之外，還須能夠承受熱所衍生之負荷。


BÖHLER

最高品質之
特殊鋼
SPECIAL STEELS
IN TOP FORM

An optimal combination of both mechanical as well as metallurgical properties allows for:

In the production of the tool steel:
» Easy machining and superior machinability
» Safe and simple heat treatment
» The best dimensional stability during heat treatment

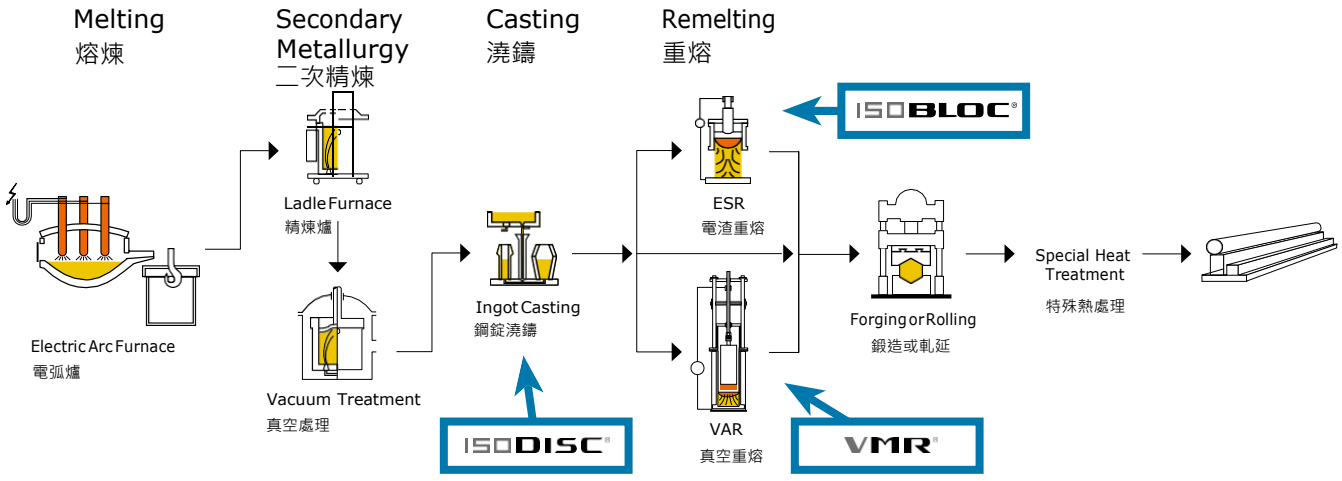
In use:
» Long and uniform tool life time
» Maximum security against failure

機械性能和冶金特性的最佳組合，可提供給您：

工具鋼工具製造中:
» 易於加工並有卓越可加工性
» 安全並易於熱處理
» 最佳熱處理尺寸安定性

使用過程中:
» 模具壽命長，且穩定可預測
» 提升最大安全性，防止失效

百樂熱作鋼的生產步驟
Production routes for BÖHLER hot work tool steels

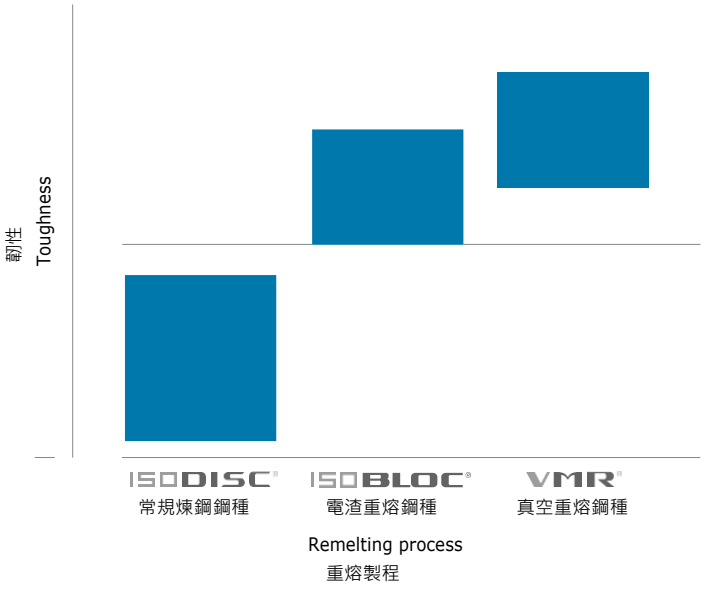


性能 Property	定義 Definition	效益 Benefits
Hot toughness **高溫韌性**	The resistance of a material to crack formation and crack growth. The toughness of hot work tool steels increases as the temperature rises. 材料抵抗裂痕形成和裂痕擴展之能力。 熱作工具鋼韌性隨著溫度升高而提昇。	On tools with deep engraving at corss-sectional variations and edges high mechanical stress can develop, leading to thermal cracks. An increase in toughness **thus reduces the risk of crack formation** and contributing greatly to **resistance to crack formation.** 在工具各種不同截面深度進行深雕或邊緣加工，會產生高機械應力，從而導致熱裂紋。 因此韌性之提高得以**降低裂痕形成風險**，並大幅地提高抵抗裂紋形成之能力
Hot strength **高溫強度**	The ability of a material to absorb stress without deformation. If the microstructure changes due to the high temperatures, the strength at room temperature and subsequently the strength at service temperature decreases. 材料吸收應力而不變形之能力。 如果金相組織因高溫而改變，則在室溫的強度會隨工作溫度上升而降低強度。	With sufficient strength even at high temperatures the security **against deformation** of the tools increases. 即使在高溫下也具有足夠強度，能夠提高模具抵抗變形之安全能力
Retention of hardness **抗回火軟化性**	The resistance of a material to softening at elevated temperatures. 材料在溫度提升時抵抗軟化之能力。	With sufficiently good tempering properties **sufficient working hardness** even at high temperatures will be guaranteed. 有夠好的回火特性，即使在高溫下也能確保**足夠的工作硬度**。
Hot wear resistance **高溫耐磨耗性**	The resistance to loss of material on surfaces brought about by mechanical causes. 機械原因引起的表面材料損失的抵抗力。	With sufficient hot wear resistance the **risk of erosion** is reduced. 具有足夠高溫耐磨耗性，降低**侵蝕風險**。
Thermal shock resistance **抗熱疲勞性**	The ability of material to stand periodic loads due to cyclic temperature changes. 材料由於週期性溫度變化而承受週期性負載的能力。	The reticular heat checking formed on the surfaces due to change in temperature **are delayed**. 能夠**延緩**因溫度變化而在模具表面產生的熱龜裂。
Thermal conductivity **熱傳導性**	The speed at which heat from a single point spreads throughout the material. 熱從單點擴散到整個材料的速度。	On the one hand, with high thermal conductivity the temperature gradient leading to thermal stress is reduced. On the other hand, the damaging temperature is transported away from the surface. This brings about a **reduction in deformations, heat checking and gross cracking**. 由於導熱係數高，會使引起熱應力之溫度梯度降低。 另一方面，破壞性溫度得以從表面迅速分散，這將降低變形量，**熱龜裂與降低明顯開裂的發生。**

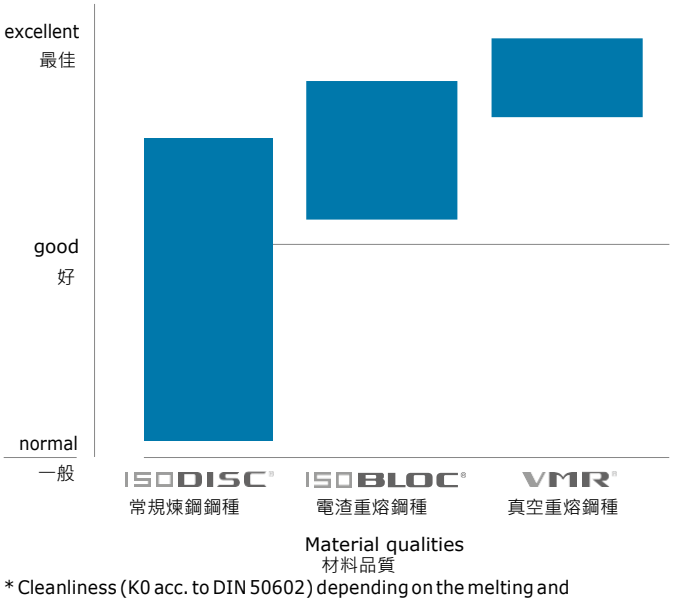
For the most part these properties are characterized by metallurgic features and thus are regulated during the melting of the hot work tool steel. Our experience and on-going research lead to the continuous improvement of these metallurgic properties through advancements and further developments in the melting and remelting processes.

這些特性大部分以冶金特性為主，因此可以在熱作工具鋼的熔煉過程中調節。 百樂鋼的經驗和長期不斷的研究進一步改善了熔煉和重熔工藝，進而提高了這些冶金特性。

重熔製程 vs. 韌性
Remelting process vs. toughness



清淨度
Cleanliness (K0 acc. to DIN 50602)*



* Cleanliness (K0 acc. to DIN 50602) depending on the melting and remelting process

* 鋼材清淨度取決於熔煉及重熔製程

鋼種特性比較
COMPARISON OF STEEL PROPERTIES

Qualitative comparison of the major steel properties

This table is intended to support the steel choice. It does not, however, take into account the various load conditions imposed by the different types of applications. Our technical consultancy staff will be glad to assist you in any questions concerning the use and processing of steels.

主要鋼種性能的量化比較

以下表格用於協助使用者選擇適用鋼種，但未將不同應用情形對模具產生的負荷納入考量。我們的技術顧問人員很樂意協助您有關鋼材使用和加工的任何問題。

百樂鋼鋼種 BÖHLER grade	高溫強度 High temperature strength	高溫韌性 High temperature toughness	高溫耐磨耗性 High temperature wear resistance	加工性 Machinability
BÖHLER W300 ISODISC®	★★	★★★	★★	★★★★★
BÖHLER W300 ISOBLOC®	★★	★★★★	★★	★★★★★
BÖHLER W302 ISODISC®	★★★	★★★	★★★	★★★★★
BÖHLER W302 ISOBLOC®	★★★	★★★★	★★★	★★★★★
BÖHLER W303 ISODISC®	★★★★	★★★	★★★★	★★★★★
BÖHLER W320 ISODISC®	★★★	★★	★★★	★★★★★
BÖHLER W350 ISOBLOC®	★★★	★★★★★	★★★	★★★★★
BÖHLER W360 ISOBLOC®	★★★★★	★★★★	★★★★★	★★★★★
BÖHLER W400 VMR®	★★	★★★★★	★★	★★★★
BÖHLER W403 VMR®	★★★★	★★★★	★★★★	★★★★
BÖHLER W720 VMR®	Maraging steels (ageing temperature about 480 °C), in this form not comparable with the heat treatable steels. 麻時效鋼 (時效溫度為約480 °C) 在這個狀況下無法與可熱處理之鋼種相比			
BÖHLER W722 VMR®				

鋼種成分分析
CHEMICAL ANALYSIS

百樂鋼鋼種	合金成分百分比								對應標準牌號		
BÖHLER grade	Chemical composition in %								Standards		
	C	Si	Mn	Cr	Mo	Ni	V	Others	DIN/ EN	AISI	AFNOR
BÖHLER W300 [1] ISOBLOC	0.38	1.10	0.40	5.00	1.30	–	0.40	–	<1.2343> X38CrMoV5-1	H11	Z38CDV5
BÖHLER W302 [1] ISOBLOC	0.39	1.10	0.40	5.20	1.30	–	0.95	–	<1.2344> X40CrMoV5-1	H13	Z40CDV5
BÖHLER W303 ISODISC	0.38	0.40	0.40	5.00	2.80	–	0.55	–	<1.2367> X38CrMoV5-3	–	–
BÖHLER W320 ISODISC	0.31	0.30	0.35	2.90	2.80	–	0.50	–	<1.2365> 32CrMoV12-28 (X32CrMoV3 3)	H10	32DCV28
BÖHLER W350 ISOBLOC	0.38	0.20	0.55	5.00	1.75	–	0.55	–	–	–	–
BÖHLER W360 ISOBLOC	0.50	0.20	0.25	4.50	3.00	–	0.55	–	–	–	–
BÖHLER W400 VMR	0.37	0.20	0.25	5.00	1.30	–	0.45	–	1.2340 ~ X37CrMoV5-1	~ H11	Z36CDV5 ~ Z38CDV5
BÖHLER W403 VMR	0.38	0.20	0.25	5.00	2.80	–	0.65	–	~ 1.2367 ~ X38CrMoV5-3	–	~ Z38CDV5-3
BÖHLER W720 VMR	max. 0.005	max. 0.05	max. 0.10	–	5.00	18.50	–	Co = 9.00 Ti = 0.70 Al = 0.10	~1.2709	–	–
BÖHLER W722 [2] VMR	max. 0.005	max. 0.05	max. 0.05	–	4.90	18.00	–	Co = 9.30 Ti = 1.00	<1.2709 >	–	–

[1] also available in ISODISC quality 也提供常規煉鋼之等級
[2] Special grade, please enquire before ordering 特殊鋼種，在下訂之前請先詢問

百樂鋼種 BÖHLER grade	應用 Applications	
BÖHLER W300 [1] SOBLOC	Primarily for the processing of light metal alloys 主要用於低合金金屬的加工	Highly stressed hot work tools, such as mandrels, dies and containers for metal tube and rod extrusion. 承受高壓之熱作模具，例如擠型金屬管及棒材的心軸、模具及容器。 Hot extrusion tools, die casting tools, forming dies, die inserts, hot shear blades. 熱擠壓模具，壓鑄模具，成型模具，模具嵌塊，熱切割刀片。 Tools for the manufacture of hollows, tools for the manufacture of screws, nuts, rivets and bolts. 空心成品之模具，螺絲，螺帽，鉚釘和螺栓的工具。
BÖHLER W302 [1] SOBLOC		
BÖHLER W303 SODISC		
BÖHLER W320 SODISC	Primarily for the processing of heavy metal alloys 主要用於高合金金屬的加工	
BÖHLER W350 SOBLOC	Primarily for the processing of light metal alloys 主要用於低合金金屬的加工	
BÖHLER W360 SOBLOC	Primarily for the processing of heavy metal and light metal alloys 主要用於高、低合金金屬的加工	Dies and punches in warm and hot forging. Tooling for high speed presses. Toughness-critical cold work applications. Extrusion tooling, e.g. dies. Core pins and inserts in die-casting dies. Specific applications in the plastic processing sector. 溫鍛和熱鍛的模具與沖頭。高速沖壓的模具。高度要求韌性的冷作鋼應用。擠型模具。壓鑄模具中的芯銷和嵌件。 在塑膠加工領域的特定應用。
BÖHLER W400 VMR	Primarily for the processing of light metal alloys 主要用於低合金金屬的加工	Highly stressed hot work tools, such as mandrels, dies and containers for metal tube and rod extrusion. Die casting tools, forming dies, die inserts, hot shear blades. Hot extrusion tools, tools for the manufacture of hollows, tools for the manufacture of screws, nuts, rivets and bolts. 高應力的熱作模具，例如擠型金屬管及棒材的心軸、模具及容器。 壓鑄模具，成型模具，模具嵌塊，熱切割刀片。 熱擠型模具，空心成品之模具，螺絲，螺帽，鉚釘和螺栓的工具。
BÖHLER W403 VMR		
BÖHLER W720 VMR	Hot and cold work tool steel for long-time service up to abt. 450 °C. Tools for hydrostatic presses, cold extrusion tools, cold heading and embossing tools, moulds for the plastic industry, die casting tools for aluminium and zinc alloys, hot pressing tools, cold pilger mandrels. 可在約450°C的溫度下長期使用的冷熱工作工具鋼。液壓用模具，冷擠型模具，冷鍛與壓花模具，塑膠模具，鋁/鋅合金壓鑄模具，熱壓模具，冷軋管心軸。	
BÖHLER W722 VMR	Cold heading and embossing tools, cold extrusion tools, casings, shear plates, moulds for the plastic industry, die casting tools for aluminium and zinc alloys, hot pressing tools. 冷鍛與壓花模具，冷擠型模具，壓鑄模具，切割刀片，塑膠模具，鋁/鋅合金壓鑄模具，熱壓模具。	

[1] also available in ISODISC quality 也提供常規煉鋼之等級

BÖHLER Die Casting Concept

HIGH PRESSURE DIE CASTING PROCESS 高壓壓鑄工藝

DIE CASTING 壓鑄

In die casting liquid metal is injected into a die of the exact shape in which, under pressure, it solidifies. Meltings processed in this manner encompass materials with lower melting points such as tin, lead and zinc alloys, those with mid-range melting points such as aluminium or magnesium and their alloys, up to copper alloys with higher melting points.

In the **cold chamber die casting process** the melting of the metal to be processed is drawn in portions from a dosing furnace and filled into a casting chamber by means of a ladling device. Afterwards the metal that was poured in is pressed into the die with a hydraulically driven plunger. Due to the fact that the casting chamber does not come into contact with the liquid melting during the entire casting process, thus is cold in contrast to the melting, the term cold chamber process is used. In the **hot chamber die casting process** the casting chamber is in constant contact with the melting. This chamber is at casting temperature.

壓鑄的過程為: 將金屬液注入精密模具中，保壓下使之固化。適用此法之金屬有低溶點金屬材料，如錫、鉛和鋅合金；中等範圍溶點之材料，例如鋁或鎂及其合金；以及更高熔點之銅合金。

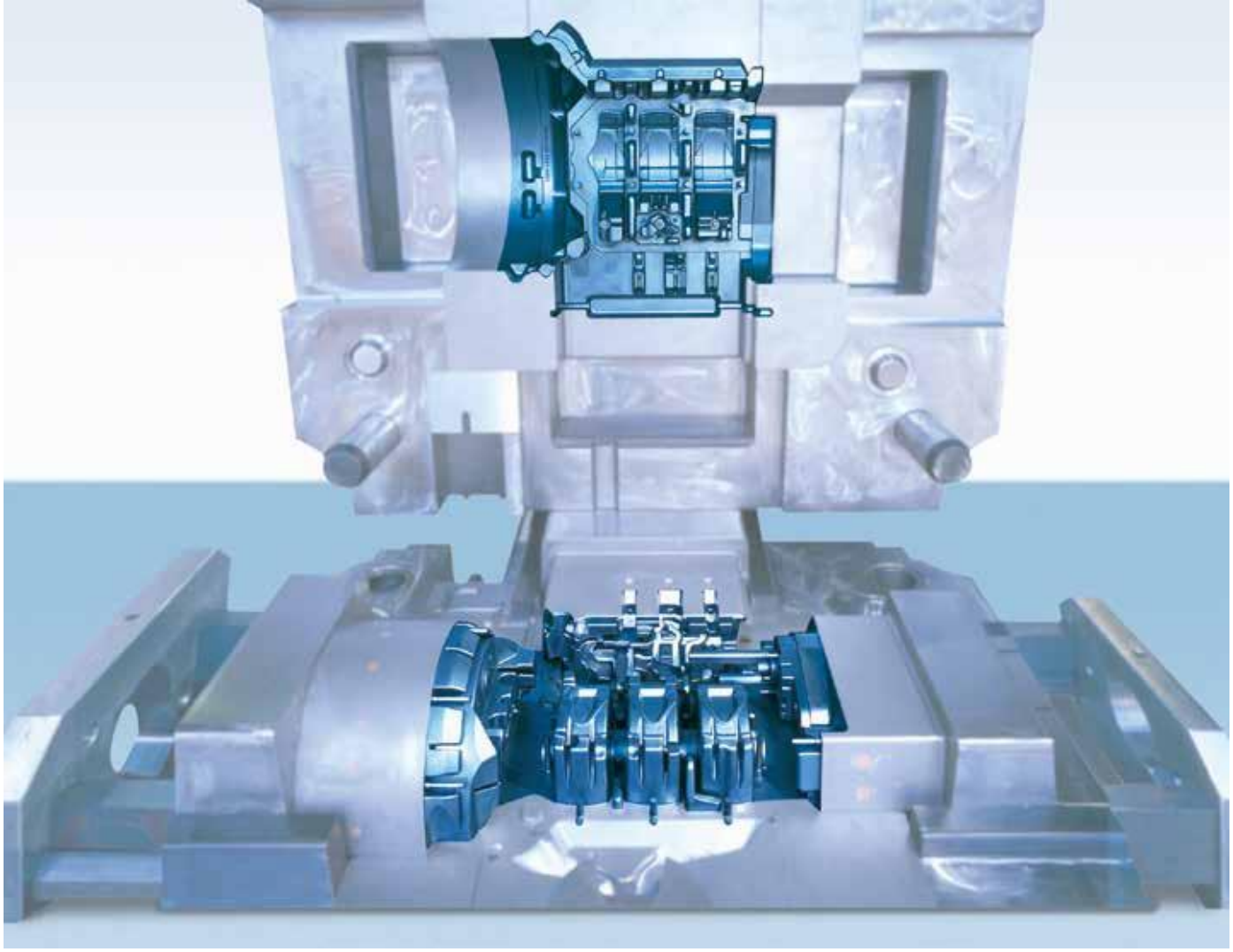
Since aluminium alloys and copper alloys react with the steel of the casting chamber, a longer contact of this melt with the tool components leads to erosion and corrosion. For this reason these metals are processed using the cold chamber procedure. In order to be able to guarantee even casting of the dies without premature solidification on thin gage parts as well, the melt is moulded under pressure of 200 – 300 bar. Due to these high pressure conditions the casting processes take place correspondingly quickly. Even the dies of aluminium castings weighing several kilograms are filled within seconds.

Nowadays approximately 80% of the aluminium castings are produced using the cold chamber die casting procedure.

所謂**冷室壓鑄製程**，利用舀杓從配料爐裡取出預先融化金屬之溶液，倒入料管 (壓室)。之後透過液壓驅動柱塞將金屬液壓進模腔。由於在整個過程中，料管不同於熱室製程將料管浸泡於熔融液體內使其直接接觸，料管溫度與熔融液體相比較是冷的。因此稱之為冷室製程。在**熱室壓鑄製程**中，料管 (鵝頸管) 始終與熔融液體接觸。 該料管就會一直處於壓鑄溶液溫度

由於鋁合金和銅合金會與料管鋼材產生化學反應，長時間的接觸會造成料管的侵蝕與腐蝕，因此這類合金通常使用冷室鑄造。為了能夠確保能在模具內平順流動，避免較薄的部分過早固化，溶液在200 – 300 bar的壓力下壓鑄。由於這些高壓條件，壓鑄過程相對快速。 即使是重達幾公斤的鋁鑄件模具也可在幾秒鐘內注滿。

目前約有80%的鋁鑄件使用冷室壓鑄工藝生產。



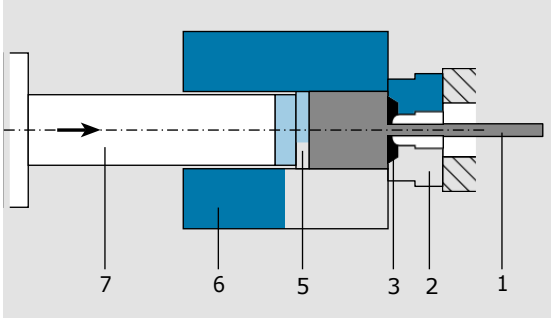
需求特性 **Requirement profile**	料管 **Casting chamber**	活塞 **Piston**	模具 **Die**	模仁 **Core**
Wear resistance 耐磨耗性	★★★★	★★	★★★	★★★
Retention of hardness 硬度維持性	★★★	★★	★★★	★★★★★
High temperature strength 高溫強度	★★	★	★★★	★★★
Heat checking resistance 抗熱龜裂性	★★	★	★★★★	★★★★★
High temperature toughness 高溫韌性	★★	★★	★★★★★	★★★

棒材擠型
ROD EXTRUSION

DIRECT EXTRUSION　直接擠型 (前擠)

Direct extrusion is the process used most often. Here the billet to be extruded is pressed towards and through the die by the stem. The friction arising between billet and liner limits the length of the container. Because the material to be extruded is always deformed at the die end of the container, not only does a higher thermal loading occur here but wear is also more extensive at this point, leading to a very one- sided loading situation.

Since this is the oldest extrusion process, some containers without controllable heating systems are still in operation. Modern direct extrusion presses are usually equipped with a zone-controlled resistance heating system and sometimes also with a cooling system, despite the comparatively short length of the container.



1 Extrusion 擠出成品
2 Die holder 壓環
3 Die 模具
4 Billet 擠碇
5 Dummy block 壓餅
6 Container 盛錠筒
7 Stem 壓桿

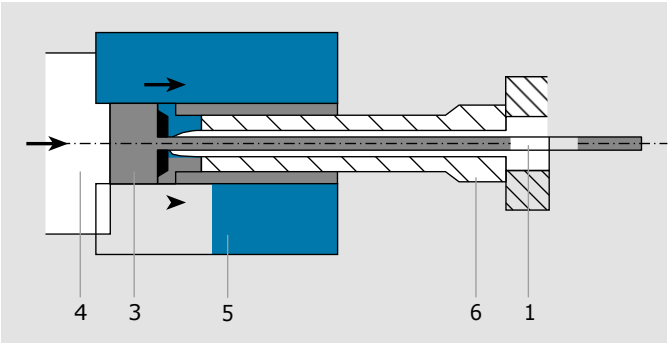
直接擠型是最常見的擠型製程，在此利用壓桿將胚料向前擠壓並使其料穿過模具。盛錠筒的長度受限於坯料和襯套之間產生的摩擦力，而由於材料經由受壓，再透過盛錠筒之末端模具成形，因此在模具端有極大的熱負荷之外，也較其他部位產生更大的磨耗，造成單側有較大的負載狀況。

由於這是早期的擠型工藝，因此至今仍可見到無可控加熱系統的盛錠筒仍在產線運行。 現代直接擠型機通常配備有電阻式分區加熱控制系統，有時還備有冷卻系統。而這種盛錠筒之長度相對上是較短的。

INDIRECT EXTRUSION　間接擠型 (後擠)

The indirect extrusion process has gained significant importance in the last few years. In this process the container, with the billet, is pressed directly against the hollow stem, with the result that the friction between billet and liner becomes negligible thus lowering the necessary force. This enables the use of very long containers. The resulting long press times lead to higher thermal stresses in the container components.

Since the extruded material must pass through the bore in the stem, the diameter of this bore limits the dimension of the extrusion which can be produced. In order to be able to produce a wide range of products despite this, the hollow stem is usually designed with a large bore which in turn leads to a high compressive stress on the stem and so necessitates careful selection of materials. Most indirect presses are equipped with containers over 1200 mm in length, meaning that multi-zone heating systems and cooling systems are standard.



1 Extrusion 擠出成品
2 Dummy block with die 壓餅與模具
3 Billet 擠碇
4 Sealing plug 封閉塞
5 Container 盛錠筒
6 Stem 壓桿

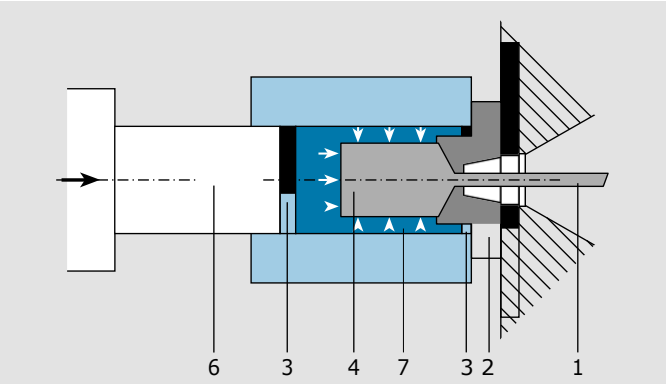
間接擠型在過去幾年變得越來越重要，在此製程，於盛錠筒內裝有胚料對著中空壓桿直接受擠壓，其胚料則由壓桿中心空心處擠出，因此胚料與襯套之間的摩擦則可忽略，降低了擠壓所需加壓力量。長度極長之盛錠筒也可以使用在此製程，但壓製時間也會延長，並使盛錠筒中零件產生更高的熱應力。

由於擠壓的材料必須穿越壓桿中心的孔洞，因此該孔洞的直徑限制了可以製造擠壓件之尺寸。為了能夠盡量生產多樣產品，空心壓桿之孔徑需求通常設計要大孔，這又導致壓桿需承受高壓應力，因此需要仔細選擇材料。 大多數間接擠型機都配有長度超過1200mm之盛錠筒，代表多區段加熱系統與冷卻系統在此製程中是標準配備。

HYDROSTATIC EXTRUSION 液靜壓擠型

Hydrostatic extrusion is a relatively rare process and is primarily used only for products which are otherwise difficult to manufacture. This process is usually operated at very high pressures so that the container components are subject to a high degree of material fatigue. These tools are a particular challenge for tooling suppliers. Our VMR qualities with the best material properties have proven to be a good solution here.

液靜壓擠型是一種相對罕見的工藝，僅應用於難以用其他方式製造之產品。該製程通常在非常高壓下進行，會使盛錠筒零件承受高度材料疲勞。這些模具對模具供應商來說是一項特殊挑戰。我們擁有最佳性能之VMR(真空熔煉)品質鋼材，在過去成功案例中已被證實為一個很好的解決方案



1	Extrusion	擠出成品	4	Billet	擠碇	7	Hydrostatic medium 液壓介質
2	Die	模具	5	Container	盛錠筒		
3	Seal	密封	6	Stem	壓桿		

特性要求 **Requirement profile**	外套/束套 **Mantle**	內襯支架 **Liner holder**	內襯/內膽 **Liner**	壓桿 **Stem**
Wear resistance 耐磨耗性	★	★	★★★★	★★
Hot hardness 高溫硬度	★★★	★★★	★★★★	★★★★
High temperature strength 高溫強度	★★★	★★★★	★★★★	★★★
Creep resistance 抗潛變性	★★★★★	★★★★★	★★★	★
Heat checking resistance 抗熱龜裂性	★	★	★★★★	★
Compressive strength 抗壓強度	★	★★★	★★	★★★★★
High temperature toughness 高溫韌性	★★★	★	★★★	★★

鍛造工藝
FORGING PROCESS

Forging is the non-cutting shaping of metals between two tools. The choice of tool steel is primarily determined by the respective forging process.

鍛造是金屬於兩工具之間以非切削方式成型，工具鋼的選擇則取決於鍛造工藝的種類

落鍛鍛造

落槌鍛造法是通過用鍛錘撞擊物料或是透過使用鍛造壓機或其他鍛造機施加大量壓力來加工。

使用**鍛錘**鍛造時，鍛造件與模具僅有短時間的接觸。 因此模具必須承受的溫度較低，但是**機械應力高**。 因此，使用具有極高韌性之熱作工具鋼非常重要。

壓力鍛造

與此相比，**壓力鍛造法的**過程中，因接觸時間方面需要較長的時間，在工具上會產生**更高的溫度應變**。 在這種情況下，應使用鉻鉬系列熱作工具鋼，因其具有良好的抗回火軟化性，高溫強度，高溫耐磨損性和高溫韌性。

快速鍛造

全自動多段壓床是**採用多階段成形法，對較難塑型材製程複雜形狀成品之設備**。這種設備時常用於生產**旋轉對稱性零件**。 過程中胚料加熱、進料、剪切到塑型均為完全自動加工。

DROP FORGING

Drop forging is carried out by impacting material with a hammer or by applying a great amount of pressure with a forging press or forging machine.

When forging with a **hammer** the forging piece is only in contact with the die for a short period of time. Due to this, the die has to withstand lower temperatures. However, the **mechanical stress is high**. Thus, it is quite important for the hot work tool steel used to have very good toughness properties.

Compared with that, the contact during **forging pressing** occurs over a longer period of time, which then causes a **higher temperature strain on the tool**. Thus, in such a case hot work tool steels with a chromium-molybdenum base are used, which are singled out as having good tempering resistance, high temperature strength, hot wear resistance, and hot toughness.

RAPID FORGING

A fully automatic multi-stage press is forging equipment that produces even the **most difficult shapes from materials hard to deform in several stages of deformation**. This equipment mostly produces **rotation symmetric parts**. Heating the slugs, feeding, shearing and deforming take place completely automatically.

溫鍛

"溫鍛"是指在設定的變形參數下，**將工件預熱至發生永久應變硬化**的變形製程。 該定義代表材料在低於再結晶溫度下加工變形，但也會在高於該溫度下進行加工。 在實際應用上，大致是在650至950℃左右溫度範圍內對鋼鐵加工。 這些溫度大大低於常規鍛造溫度1100 – 1250°C。

SEMI HOT FORGING

The term semi hot forging refers to a deformation process in which **the workpiece is preheated to such a point that permanent strain hardening** occurs under the given deformation conditions. This definition means that the material is deformed below the recrystallization temperature, yet the term is also used for temperatures occurring above this. In practice this is understood to be the deformation of steel in the temperature range of 650 to approx. 950 °C. These temperatures lie significantly below the conventional forging temperatures of 1100 – 1250 °C.

特性要求 **Requirement profile**	落槌鍛造 **Drop forging with hammer**	壓力鍛造 **Drop forging with press**	溫鍛 **Semi hot forging**
Wear resistance 耐磨耗性	★★★★★	★★★★★	★★★★★
Retention of hardness 硬度維持性	★★	★★★★	★★★
High temperature strength 高溫強度	★★★	★★★	★★★★
Heat checking resistance 抗熱龜裂性	★	★★	★
High temperature toughness 高溫韌性	★★★★	★★★	★★

ERODING　放電加工

In the eroding process material on the surface is melted and is withdrawn drop by drop by means of a local electrical discharge. By melting the surface a quickly solidified, untempered martensitic layer, the so-called white layer, is formed. This layer is very brittle and cracks may easily form in this region, disseminating in the base material. In order to minimize the formation of cracks to a great extent the rough pre-machining should always be followed by fine eroding. Low levels of current strength and a high rate of pulse frequency reduce the thickness of the area influenced.

Afterwards the layer should be removed by grinding or polishing or the tool should be tempered 30 °C below the last tempering temperature. Should none of these options be possible, the crack propagation can be reduced by raising the toughness of the tool steel.

Impurities in the dielectric can lead to stray field electrolysis, whereby material is removed in an uncontrolled manner by unwanted discharges. For this reason the quality of the fresh water should be checked on a regular basis. Further information can be found in our pamphlet „EDM Machining of Tool Steels“.

在放電侵蝕過程中，局部放電下材料表面會被溶化並一點一滴的排出。而熔化後表面則會快速凝固，形成未回火之麻田散鐵層，即所謂的白層。白層非常脆，容易形成裂紋，並傳播進入基材。為了大幅度地減少裂紋的形成，應於粗加工之後進行細微放電。較低的電流強度和較高的脈衝頻率會減小受影響區的厚度。

之後應通過研磨或拋光去除白層，或於最後回火溫度再低30°C之溫度下再進行一次回火。如果這些選擇都不可行，則可以通過提高工具鋼的韌性來減少裂紋擴展。

介電質液體中的雜質會導致電解場雜散，再多餘不受控制的放電下移除材料。因此，應定期檢查液體的品質。若需要更多的資訊，請參見我們的手冊"工具鋼的EDM加工"。

HEAT TREATMENT　熱處理

Nowadays heat treatment is not primarily used to regulate the targeted hardness, but rather it influences numerous mechanical properties such as toughness or thermal shock resistance. For this reason it is necessary to treat the BÖHLER high performance steels according to exactly prescribed instructions found in the respective product pamphlets.

Particularly in the hot work tool steel segment the tools are often of enormous dimensions. These dimensions often pose a challenge for the heat treatment process. Hardening should be done in a salt bath or in a vacuum. In order to avoid gross cracking during the heating up, this phase should take place slowly particularly in the lower range, in order to allow for a temperature equalization between the core and the surface.

For this reason at least three pre-heating phases should be planned. In order to obtain optimal structural conditions quick quenching of the hardening temperature is necessary. A warm bath simulation is recommended In order to avoid cold cracks here.

如今，熱處理的主要目的不在調節材料硬度，而是影響眾多的機械性能，例如韌性或抗熱衝擊性。因此，必須按照各產品手冊中的完整指示說明來處理BÖHLER高性能鋼種。

特別是在熱作工具鋼部分中，工具通常具有較大尺寸。對熱處理來說非常具有挑戰性。硬化應在鹽浴或真空中進行。為了避免在加熱過程中出現嚴重裂紋，升溫設定要緩慢，使中心和表面之間的溫度相近。

因此應該計劃至少三個預熱階段。為了獲得最佳的組織條件，硬化溫度後必須快速淬火。建議進行熱浴模擬，以避免在此階段出現淬裂。

模具製造
TOOLMAKING

NITRIDING 氮化

The term nitriding is used to refer to the enriching of the surface layer of a tool with nitrogen by means of a thermochemical treatment at temperatures of approx. 500 – 580 °C. A layer consisting primarily of nitrogen compounds and thus referred to as a compound layer is formed on the surface due to the high amount of nitrogen available. Metallographically isolated from the layer, the so called diffusion layer, below it, the nitrogen remains in the mixed crystals upon quick cooling. With slower cooling acicular nitrides are precipitated.

The hard compound layer is responsible for the high degree of wear resistance of the workpiece treated and reduces the adhesive gradient and the gradient of cold welding. For this reason, tools exposed to heavy-duty wear are commonly nitrided. Nonetheless it must be considered that by nitriding the potential toughness of a material is substantially reduced. Since the compound layer is quite brittle cracks can easily be formed on nitrided surfaces which then disseminated into the base material.

氮化是指在大約500 – 580°C的溫度下進行熱化學處理而使工具形成富氮表面層之方法。 層的組成主要為複氮化物，是歸因於在表面獲得大量的氮，在表面形成化合物層。金相上可區分此層下方為擴散層。快速冷卻後，氮保留混在結晶中。 慢冷則會析出針狀氮化物。

Before nitriding is performed a perfectly clean, metallically polished surface must be ensured, by means of pickling for instance. In general it should be observed that complicatedly shaped parts with different cross-sections or larger dimensions are to be heated and cooled slowly. In order for the workpiece to be nitrided to remain thermally stable at the nitriding temperature, it should first be tempered at temperatures above the nitriding temperature. Any internal stress is to be eliminated before the nitriding treatment begins by means of stress relieving.

硬質複氮化物層能夠大幅提高的工件的耐磨性，並降低黏著梯度和冷焊梯度。 因此，需要承受重負荷磨損的工具通常會進行氮化加工。 儘管如此，必須考慮到進行氮化會大幅度降低材料之潛在韌性。 由於複氮化物層非常脆，因此在氮化的表面上容易形成裂紋，然後將其擴散到基材。

在進行氮化處理之前，必須徹底清潔，確保金屬拋光面，例如通過酸洗等方式。 需要特別注意的是，不同截面之複雜的零件面或較大尺寸的工件應緩慢加熱和冷卻。 為了使氮化的工件在氮化溫度下保持穩定，應先在高於氮化溫度的溫度進行回火。在氮化處理開始之前，應先通過應力消除去除任何內部應力。

使用過程中維修

MAINTENANCE IN APPLICATION

PREHEATING　預熱

Maximum efficiency of the tool can only be obtained with correct treatment both prior to installation and during operation. In order to reduce the jolting thermal stresses from the hot metal which is being processed, and thereby reduce heat checking, the dies must be carefully preheated according to the temperatures of the material to be processed.

Preheating of the dies has to be carried out slowly and thoroughly.

工具若要達到最大效益，必須在安裝之前和操作期間進行正確的處理。為了減少來自被加工高溫材料之熱衝擊應力，從而減少熱裂，必須根據加工材料的溫度小心地對模具進行預熱。

模具的預熱必須緩慢而徹底地進行。

STRESS RELIEVING 應力消除

Stresses which arise from the continual changes in temperature and the mechanical load need to be relieved from time to time by means of an appropriate tempering treatment. Experience has shown that an intermediary stress relief improves tool life. This stress relieving treatment should take place over a period of several hours and should occur at a temperature 30 – 50 °C below the highest tempering temperature, followed by cooling in the furnace (cf. the tempering chart in the BÖHLER data sheets).

After disassembly of tools to be kept in stock, cleaning and stress relieving is recommended.

溫度和機械負載的連續變化會引起模具中的應力，需要通過時不時適當的回火處理來緩解。 根據經驗，製程中的應力消除可延長工具壽命。 應力消除熱處理應持續數小時，並且應在最高回火溫度以下30–50°C的溫度下進行，然後在爐中冷卻（參見BÖHLER數據表中的回火圖）。

卸下要入庫存放的工具後，建議先進行清潔並消除壓力再行入庫。

WELDING 銲補

Welding is often necessary with hot work tools. In general both hot work tool steels that have been annealed and those that have already been hardened and tempered are weldable. Preheating to at least 325 °C is absolutely necessary. During the welding procedure the temperature may not drop below this level and should not rise above 475 °C.

After having completed the welding procedure, a slow cooling phase is recommended. Previously annealed material should be annealed once again after the welding treatment. A tool which has already been hardened and tempered should also be brought to 30 °C below the last tempering temperature.

Further information can be found in our pamphlet „Welding in Toolmaking“.

熱作鋼工具經常需要進行焊補。 通常已經退火的熱作工具鋼和已經硬化並回火的熱作工具鋼都可以焊補。 預熱絕對須至少到325°C，在焊補過程中，溫度也不得低於該標準，並且不應高至475°C以上。

完成焊補程序後，建議緩慢冷卻。 原先前退火的材料應在焊補處理後再次退火。 已經硬化和回火的工具應於最後一次回火溫度低30°C之溫度下再次進行回火。

更多的資訊，請參考我們的 “工具製造中的焊接” 手冊。

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