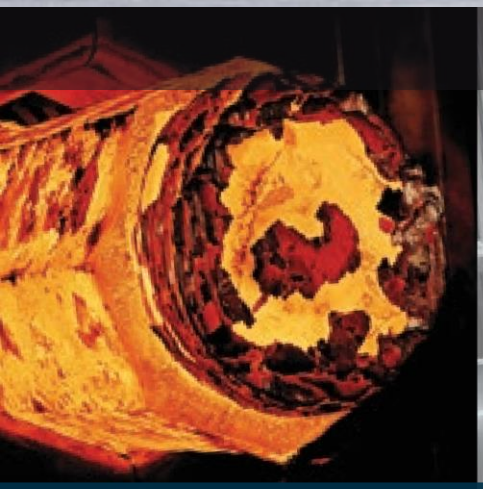
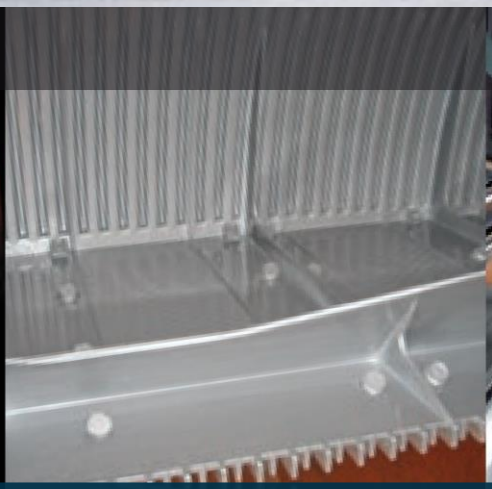
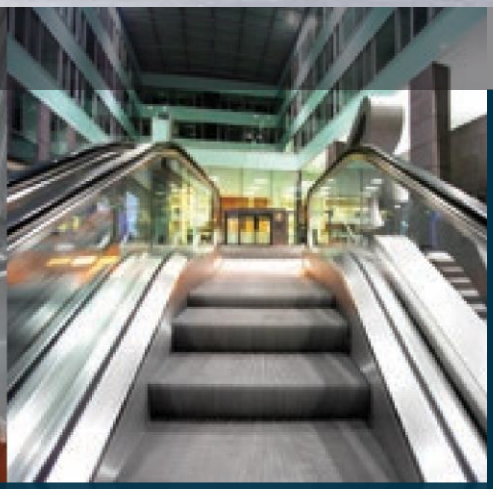
BÖHLER

熱作工具鋼

BÖHLER W350

ISOBLOC®

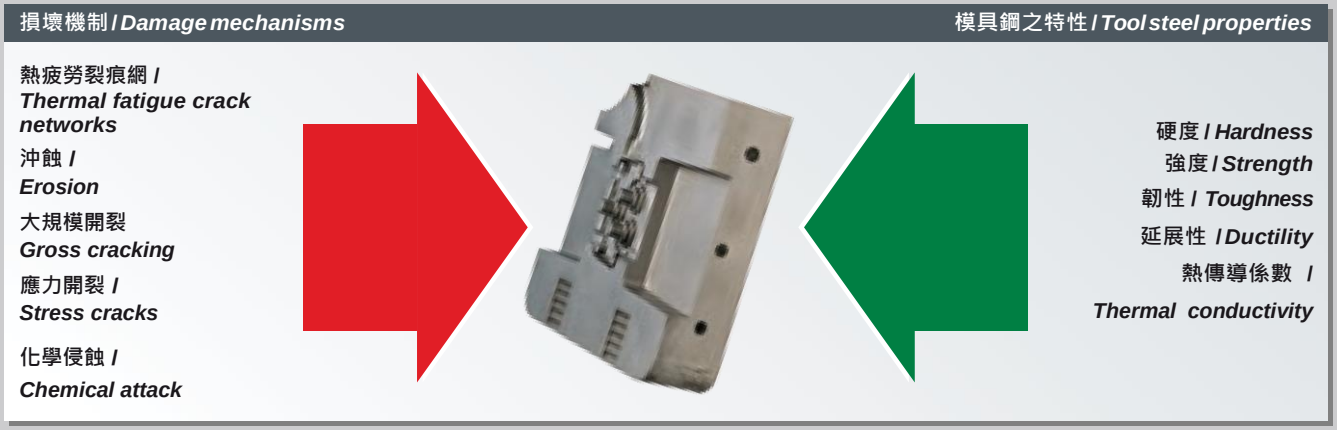
為了滿足最嚴苛的要求
FOR THE HIGHEST STANDARDS

模具負荷

應用於熱成型工藝例如壓鑄、鍛造或擠型等製成的熱作工具鋼，可能會在多種複雜的情況中損壞。造成損壞的原因可能為結合了高機械強度，高溫和溫度梯度等的集體應力因素，而取決於工藝類型和製程的各別應力因素會對材料產生可變的強烈影響。

Tool load

Hot work tool steels applied in hot forming processes such as die casting, forging or extrusion may be damaged on multiple and complex occasions. Damages may arise by collective stress factors combining high mechanical strengths, high temperatures and temperature gradients, whereas the individual stress factors dependent on process type and processing exert variably strong effects on the material.



材料硬度、材料強度、韌性、延展性和導熱性是熱作工具鋼要避免或延遲模具損耗時，須重視的重要性能

Material hardness, material strength, toughness, ductility and thermal conductivity are vital hot work tool steel properties when it comes to damage mechanisms to be avoided or delayed.


BÖHLER

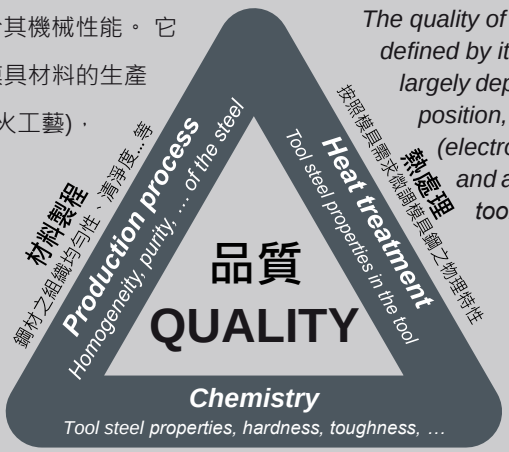
用於XXL尺寸模具之高韌性鋼材
A TOUGH STEEL FOR XXL DIES

基本原則: 須追求模具材料之最大的韌性和延展性，以避免大範圍開裂並減少熱疲勞裂紋和應力開裂。若要避免由外應力和沖蝕所引發的塑性變型，則需再追求最大韌性的同時選擇較高的硬度或強度。

There is a fundamental rule: *Maximum toughness and ductility are to be striven for in order to avoid gross cracking and to reduce thermal fatigue cracks and stress cracks. Hardness or strength should be selected in such a manner that plastic deformation caused by external stresses and erosion is prevented while aiming towards maximum toughness.*

由熱作工具鋼製成的模具的品質取決於其機械性能。 它在很大程度上則受材料之合金成分、模具材料的生產過程 (電渣重熔，真空重熔，鍛造和退火工藝)，以及最後模具的熱處理等影響而決定。

The quality of a tool made of hot work tool steel is defined by its mechanic-technological properties. It largely depends on the metal alloy's chemical composition, on the tool material's production process (electro slag remelting, vacuum remelting, forging and annealing technologies) and finally on the tool's heat treatment.



合金成分

材料基礎物理性質如硬度，韌性等

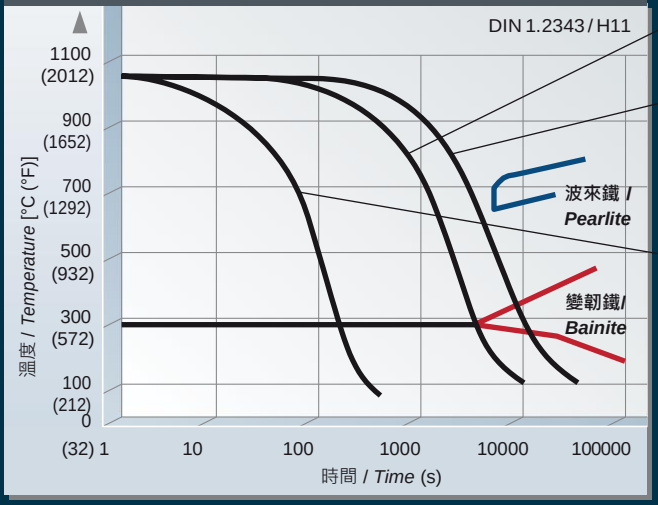
熱處理工藝

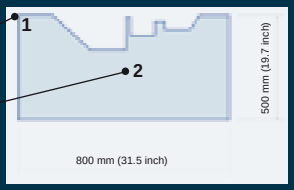
為了達到模具鋼的最高韌性，粹火過程中從硬化溫度冷卻下來的速率極為重要。冷卻速度的制定則主要取決於模具的尺寸。

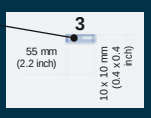
Heat treatment

In order to achieve high toughness in tools, the cooling speed from the hardening temperature is of major importance during hardening. Cooling speed is primarily dependent on the tool's size.

冷卻溫度時間關聯圖 1 / *Cooling chart 1*







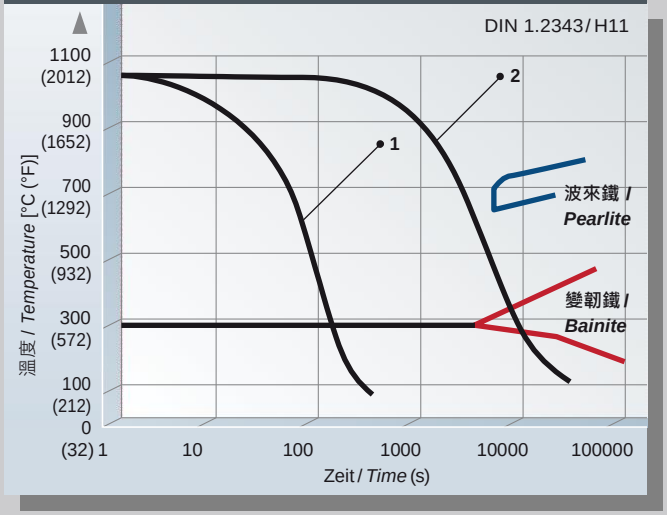
1 壓鑄模之邊角 / *Die casting die edge*
2 壓鑄模之中心 / *Die casting die core*
3 韌性試驗試片 V刻痕試驗 / *Toughness sample Charpy-V*

隨著模具厚度的增加，會導致淬火速率之降低，金相組織發生變化，從而導致韌性顯著降低（參見冷卻圖1）。

With increasing tool thickness, resulting in a reduced quenching rate, a change of microstructure occurs, leading to a significant decrease of toughness (see cooling chart 1).

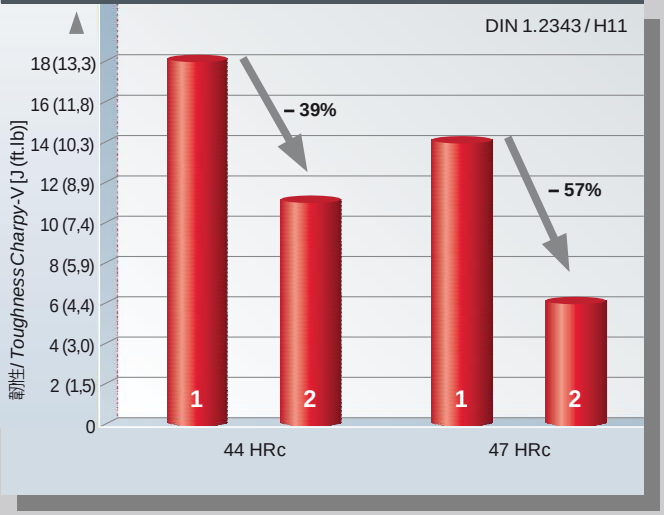
用於XXL尺寸模具之高韌性鋼材
A TOUGH STEEL FOR XXL DIES

冷卻溫度時間關聯圖 2 / *Cooling*



1 快速粹火之V刻痕韌性試驗試片 / *Fast quenching of toughness samples Charpy-V*
2 緩慢粹火之V刻痕韌性試驗試片 / *Slow quenching of toughness samples Charpy-V*

韌性之比較 / *Toughness comparison*



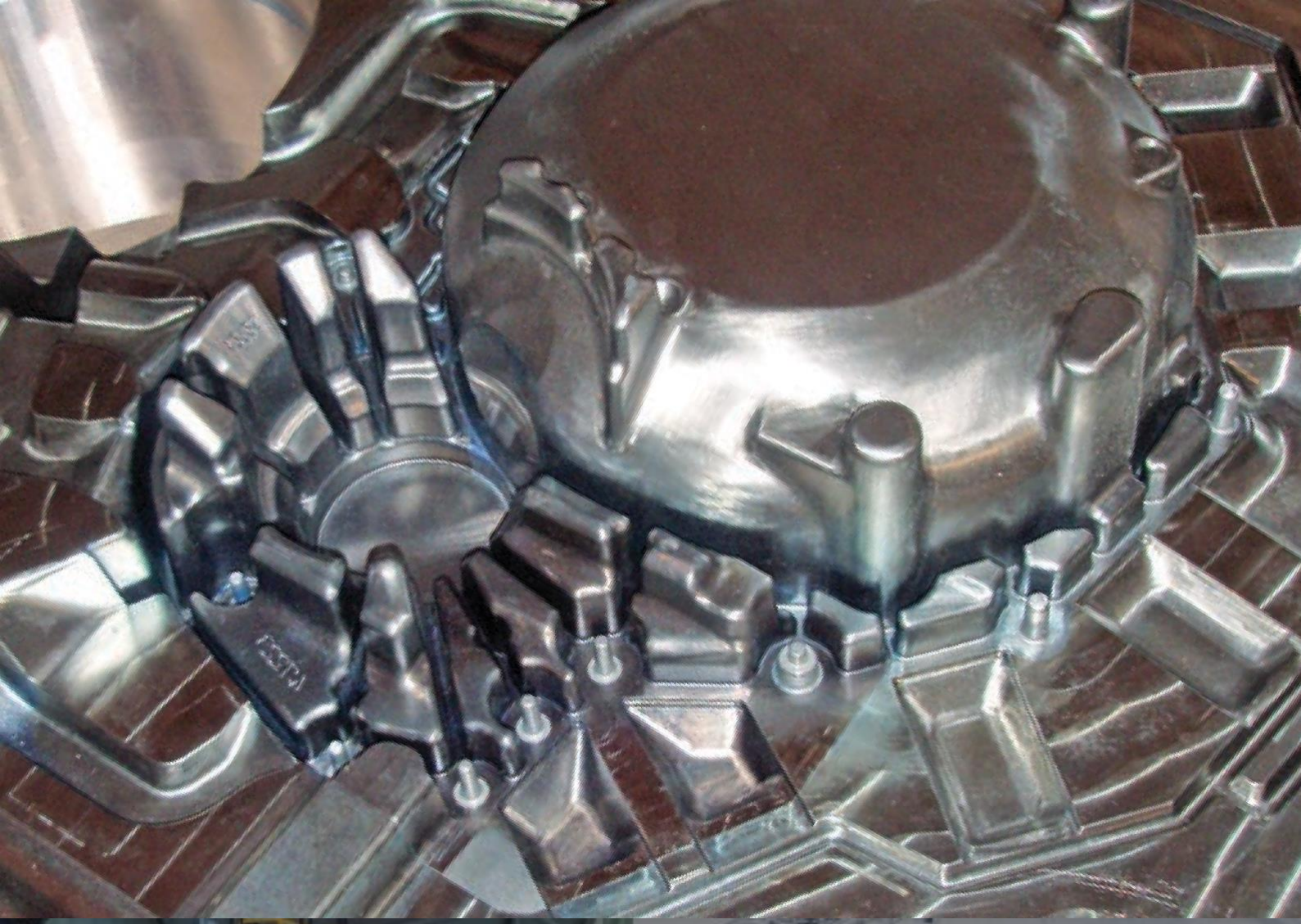
1 快速粹火 / *Fast quenched*
2 緩慢粹火 / *Slow quenched*

為了測試冷卻速率對於韌性的影響，此試驗將熱作鋼 DIN 1.2343之V刻痕試驗試片以不同冷卻速率作粹火。結果如冷卻溫度時間關聯圖2所示。

The effects of cooling speed on toughness properties were examined with hot work steel DIN 1.2343 by cooling down notched ISO-V samples at different speeds. Results are shown in the cooling chart 2.

隨著冷卻速率的降低，韌性也跟著顯著降低。另外，若硬度較高，則韌性之降低更為明顯。

The reduced cooling velocity leads to a significant decrease of toughness. If the hardness is increased, the decrease in toughness is even higher.



MECHANISCHE WERTE FÜR XXL-ZÄHIGKEIT
MECHANICAL PROPERTIES FOR XXL TOUGH

百樂鋼廠發展出W350 ISOBLOC 之鋼種，提供了使大尺寸模具得以承受熱成型複雜負荷之可熱處理調質的模具鋼種。

W350平衡的合金成分即使在大型模具的應用中也得以維持高韌性，並具有改良的熱穩定性，因此可以針對每種應用調整最佳的硬度/強度-韌性/延展性比（斷裂後的伸長率和斷裂後的面積減少率）。

With the development of W350 ISOBLOC, BÖHLER Edelstahl allows large tool sizes for the complex loads in hot forming and for effects of heat treating.

A balanced alloy composition ensuring high toughness even in large tools and an improved thermal stability opts for an optimal hardness/strength-toughness/ductility ratio (elongation after fracture and percentage reduction of area after fracture) tailor-fit to every application.

BÖHLER 牌號 *BÖHLER grade*	合金成分 / *Chemical composition* [%]							Normen / *Standards* (DIN)
	C	Si	Mn	Cr	Mo	V	N	
BÖHLER W350 ISOBLOC	0,38	0,20	0,55	5,00	1,75	0,55	def.	–

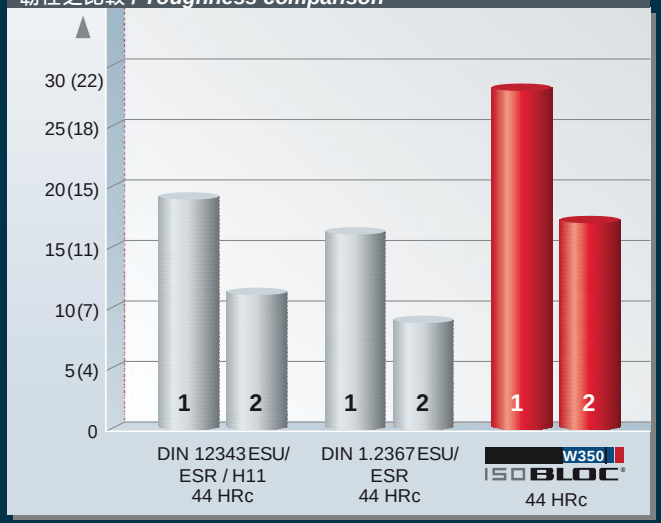
加壓的重熔工藝（加壓ESR）與優化過的鍛造技術在3D讀維度上相結合，可確保組織的高度均勻性和材料性能。 也可以確保材料的高純度。

optimized forging technology in three dimensions guarantees a high degree of homogeneity of the mircrostructure and the material properties. A high degree of purity can also be realized.

下圖所示，與常見通用材料DIN 1.2343和1.2367相比，BÖHLER W350 ISOBLOC熱作鋼的特點是無論經過快速或緩慢的冷卻淬火，均能擁有明顯較優異的韌性。

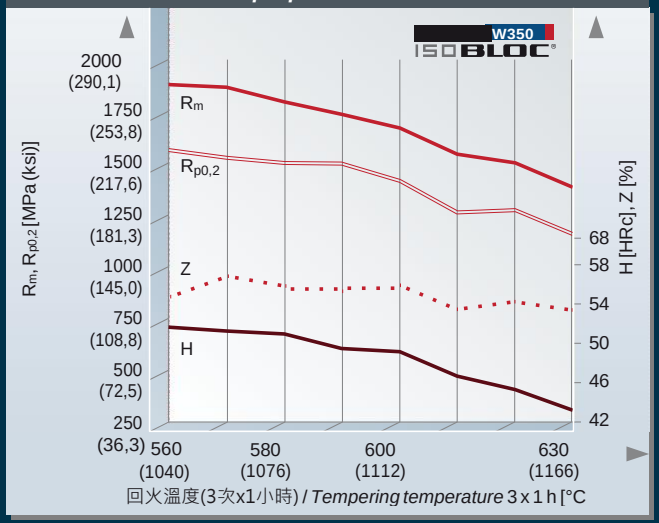
As can be seen in the image below, hot work steel BÖHLER W350 ISOBLOC is characterized by a significantly higher level of toughness for a fast and a slow cooling of the hardening temperature compared with standard materials DIN 1.2343 and 1.2367.

韌性之比較 / *Toughness comparison*



1 快速粹火 / *Fast quenched*
2 緩慢粹火 / *Slow quenched*

機械性能 / *Mechanical properties*



R_m 抗拉強度 / *Tensile strength*
$R_{p0,2}$ 降伏強度 / *Yield strength*
H 硬度 / *Hardness*
Z 縮小之面積 / *Reduction of area*

給您最長使用壽命之熱處理
HEAT TREATMENT FOR XXL LIFE TIME

出廠狀態

退火至最高 240 HB.

熱處理

退火:

800 至 850 °C.
在爐中控制以10至20°C / hr 的速度緩慢冷卻，直到大約600°C，在空氣中進一步冷卻。

Condition of delivery

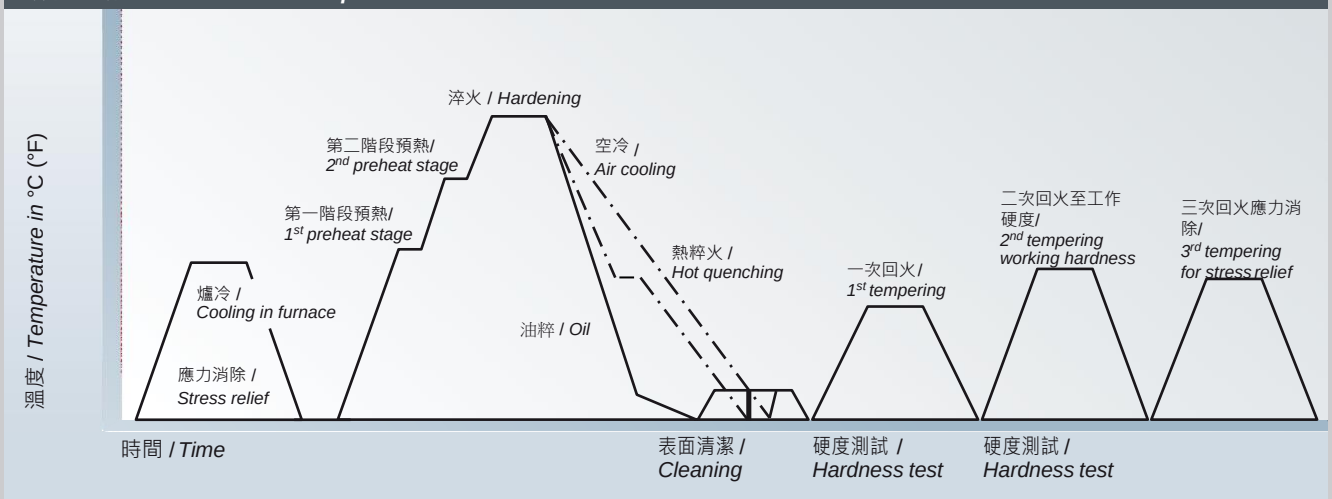
*Annealed **max. 240 HB.***

Heat treatment

Annealing:

800 to 850 °C (1472 to 1562 °F).
Slow controlled cooling in furnace at a rate of 10 to 20 °C/hr (50 to 68 °F/hr) down to approx. 600 °C (1112 °F), further cooling in air.

熱處理程序 / *Heat treatment sequence*



應力消除:

600 至 650 °C.
爐中緩慢冷卻
消除因大面積或複雜形狀之加工而產生的應力。 當內外溫度一致之後，在中性大氣中放置1-2小時

淬火:

1020 °C (1010 °C).
可油粹, 可熱粹火 (需在500 – 550 °C持溫), 可進行真空粹火。
內外溫度一致後持溫15-30分鐘。

可達硬度:
藉由油粹或麻田散鐵延遲硬化可達52 – 54 HRC;
藉由真空硬化可達50 – 53 HRC
為了避免晶粒粗大化，硬化須在建議之溫度下進行.
若尺寸較大，建議將硬化之溫度調整為1010 °C

Stress relieving:

600 to 650 °C (1112 to 1202 °F).
Slow cooling in furnace.
To relieve stresses caused by extensive machining, or for complex shapes.
Soak for 1 – 2 hours after temperature equalisation (in neutral atmosphere).

Hardening:

1020 °C (1010 °C) [1868 °F (1850 °F)]
Oil, hot quenching (500 – 550 °C [932 – 1022 °F]), air or vacuum with gas quenching. Holding time after temperature equalization: 15 to 30 minutes.

Obtainable hardness:
52 – 54 HRC by oil or delayed martensitic hardening,
50 – 53 HRC in air or vacuum hardening.
In order to prevent coarsening of the grain, hardening must be carried out at the recommended temperature.
For big dimensions it's recommended to reduce the temperature to 1010 °C (1850 °F).

達到最長模具壽命之熱處理
HEAT TREATMENT FOR XXL LIFE TIME

回火

淬火後立刻緩慢加熱至回火溫度/ 爐中持溫時間之計算方式為: 每20mm厚度加一小時，但至少需回火兩小時/ 在室溫中冷卻。建議至少回火兩次，回火第三次作為應力消除也有相當之效益。

第一次回火使用之溫度為最大二次硬化溫度以上30 °C
第二次回火達到需要之工作硬度，可以參考回火曲線圖查看平均回火溫度與硬度之對應。
第三次回火是為了進行應力消除，因此使用最高回火溫度以下30至50 °C之溫度。

Tempering

Slow heating to tempering temperature immediately after hardening/time in furnace 1 hour for each 20 mm (0.79 inch) of workpiece thickness but at least 2 hours/cooling in air.
It is recommended to temper at least twice. A third tempering cycle for the purpose of stress relieving may be advantageous.

1st tempering approx. 30 °C (85 °F) above maximum secondary hardness.
2nd tempering to desired working hardness. The tempering chart shows average tempered hardness values.
3rd tempering for stress relieving at temperatures between 30 and 50 °C (85 – 120 °F) below the highest tempering temperature.

表面處理

氮化處理:
可進行浸泡、氣體或電漿氮化處理

修補銲接

一般來說，銲接過的工具鋼容易出現裂紋。若無法避免銲接，則需要遵循適當之規範。
若需進一步之銲接資訊，請參考百樂鋼廠關於銲接之型錄

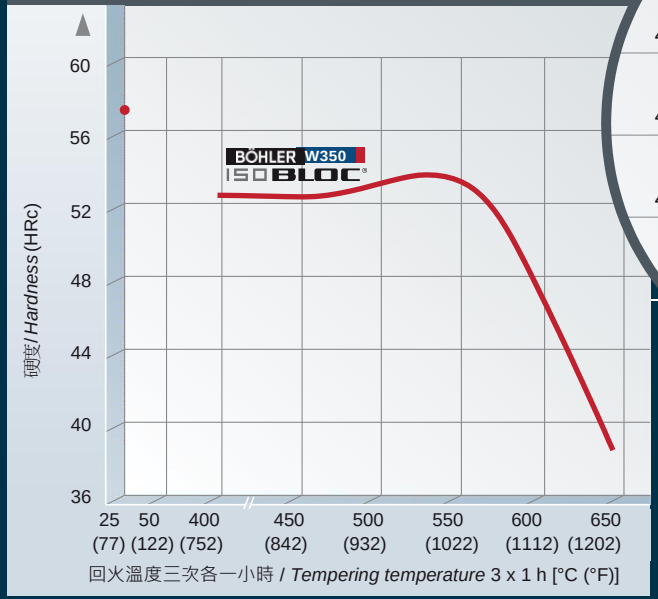
Surface treatment

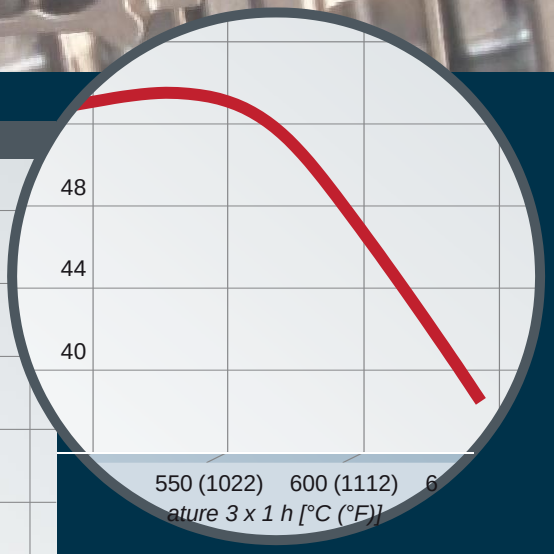
Nitriding:
Suited for bath, gas and plasma nitriding.

Repair welding

There is a general tendency for tool steels to develop cracks after welding. If welding cannot be avoided, the instructions of the appropriate welding electrode manufacturer should be sought and followed.
For further information please take a look to our welding brochure “Welding in tool making“.

回火曲線圖 / *Tempering chart*





硬化溫度: 1020 °C / *Hardening temperature: 1020 °C (1868 °F)*

大尺寸模具之熱處理
HEAT TREATMENT FOR XXL TOOLS

持續冷卻之CCT曲線 / *Continuous cooling CCT curves*

沃斯田鐵化溫度: 1020 °C
持溫時間: 15 分鐘

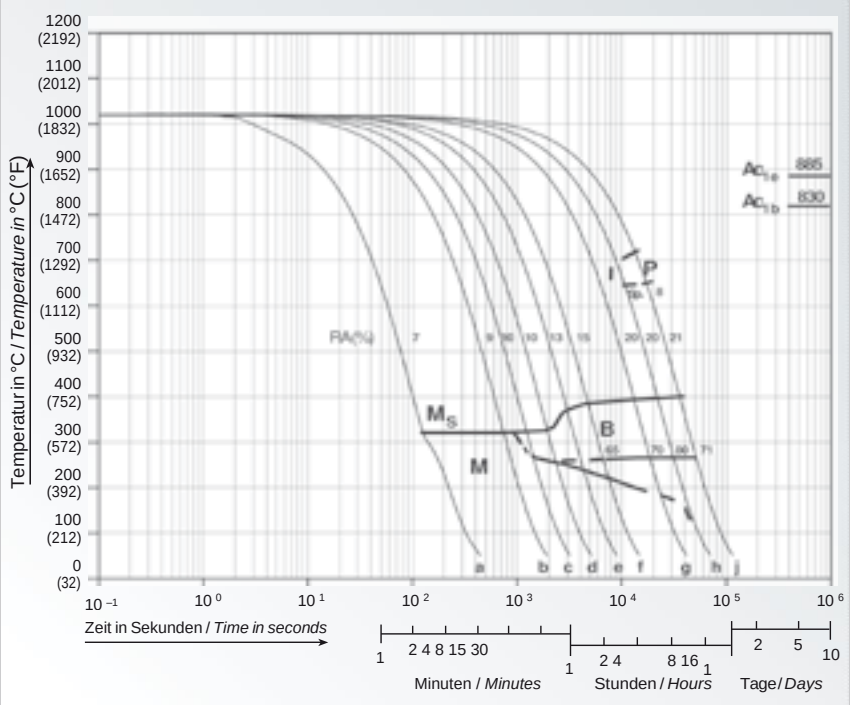
HV_{10} 維式硬度
λ 冷卻系數,例如: 從800至 500 °C 所需之時間(s x 10^{-2})

Austenitizing temperature: 1020 °C (1868 °F)
Holding time: 15 minutes

HV_{10} Vickers hardness
λ *Cooling parameter, i.e. duration of cooling from 800 – 500 °C (1472 – 932 °F) in s x 10^{-2}*

試片 / *Sample*	λ	HV_{10}
a	0,5	630
b	3	616
c	5	606
d	8	606
e	14	517
f	23	478
g	65	497
h	110	454
j	180	459

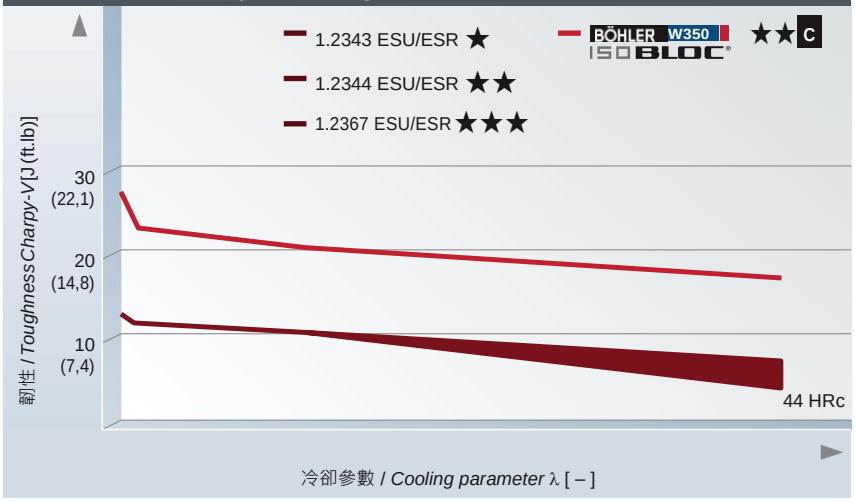
Chemische Zusammensetzung / *Chemical composition* [%]						
C	Si	Mn	Cr	Mo	Ni	V
0,38	0,21	0,50	4,95	1,75	0,04	0,53



在一般原則來說，所有通用之熱作鋼鋼種在粹火之冷卻速率降低時韌性也會隨之降低。百樂研發之新熱作鋼種W350 ISOBLOC 之設計使其得以在冷卻參數較低之急速冷卻階段，仍能達到極高之韌性，並確保在較高冷卻參數(冷卻速率降低)的情況之中仍能將韌性的降低控制在一定的範圍之中。

As a basic principle, all of the classic hot work steels display a decrease in toughness as the cooling speed of the quenching temperature is reduced. The new hot work steel BÖHLER W350 ISOBLOC was designed in such a way that during a rapid cooling phase with lower cooling parameters, very high toughness values will be able to be achieved and these values are also only marginally reduced when the cooling speed is reduced (higher cooling parameters).

韌性比較示意圖 / *Comparison toughness*



熱安定性:

★ 一般
★★ 加強
★★★ 高
C 加強之熱傳導性

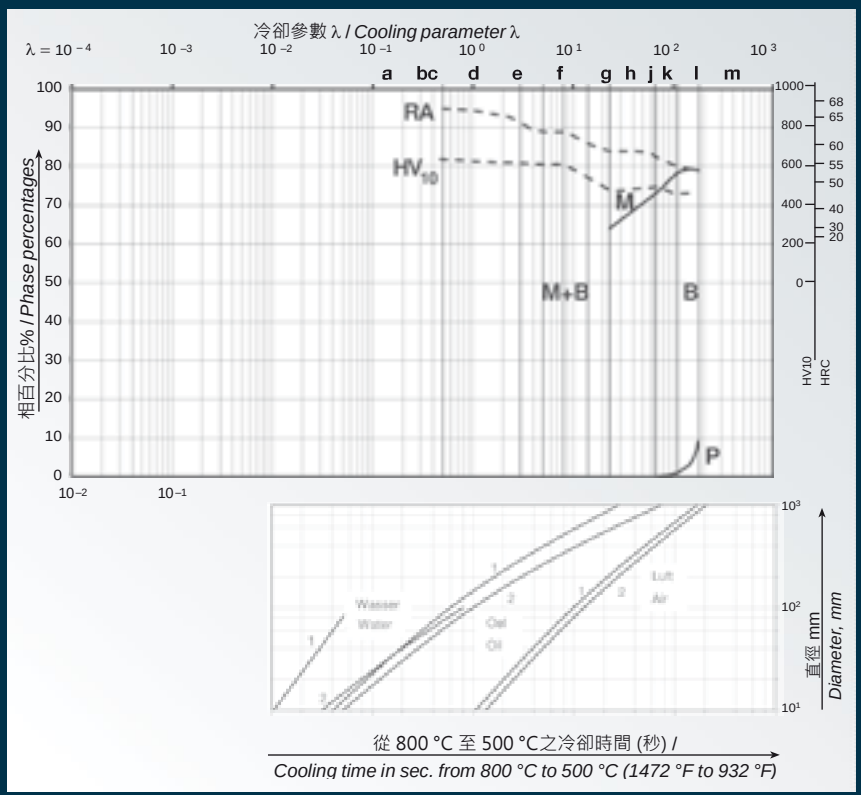
Thermal stability:

★ *standard*
★★ *improved*
★★★ *high*
C *improved thermal conductivity*

相圖 / *Quantitative phase diagram*

A. 沃斯田鐵/ *Austenite*
B. 變韌鐵 / *Bainite*
K. ..... 碳化物 / *Carbide*
P.....波來鐵 / *Perlite*
M. ..... 麻田散鐵 / *Martensite*
RA.....殘留沃斯田鐵/ *Retained austenite*
M_S .....麻田散鐵變態起始點/ *Martensite start*

1. 表面位置 / *Edge or surface*
2. 芯部位置 / *Core*

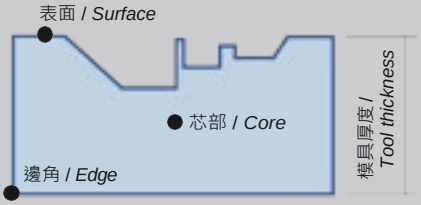


物理特性

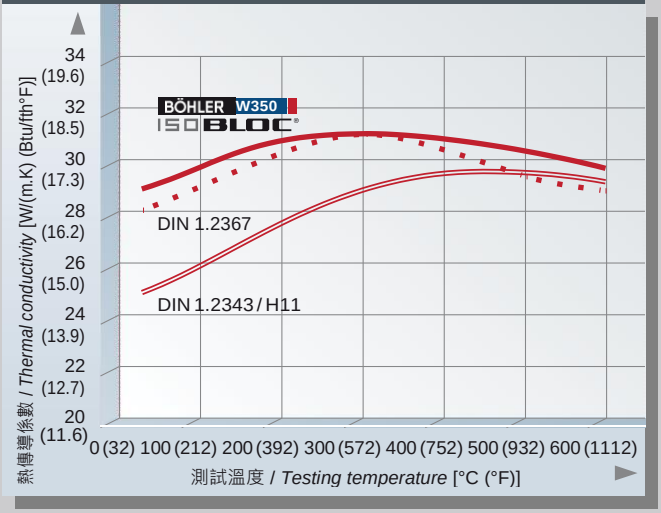
PHYSICAL PROPERTIES

氮氣淬火後的回火製程之冷卻速率須以模具尺寸以及形狀來制定。

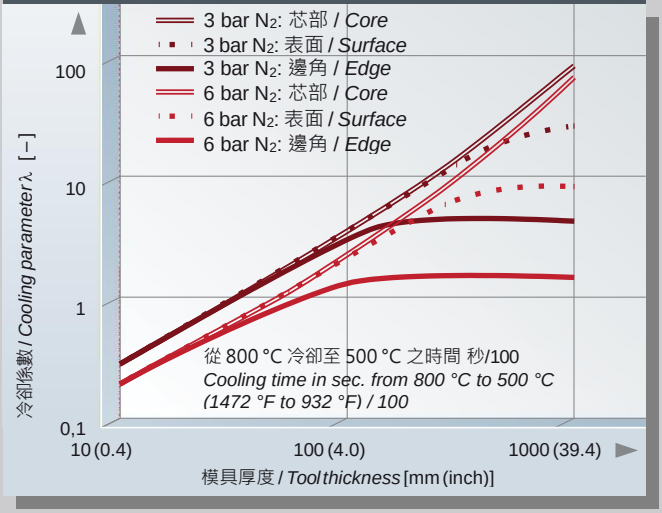
The cooling parameter set during tempering with gas quenching (N_2) is primarily dependent upon the size of the tool and its geometry.



熱傳導係數 / *Thermal conductivity*



冷卻系數 / *Cooling parameter*



物理特性 / *Physical properties*	
出廠條件: 預硬 / *Condition: hardened and tempered*	
在20 °C時的彈性系數 / *Modulus of elasticity at 20 °C* *Modulus of elasticity at 68 °F*	214,3 x 10^3 MPa 31.1 x 10^3 ksi
在20 °C時的密度 / *Density at 20 °C* *Density at 68 °F*	7,8 kg/dm^3 0.282 lbs/in^3
在20 °C時的比熱容量 / *Specific heat capacity at 20 °C* *Specific heat capacity at 68 °F*	455 J/(kg.K) 0.109 Btu/lb°F
在 20 °C時的熱傳導係數 / *Thermal conductivity at 20 °C* *Thermal conductivity at 68 °F*	28,9 W/(m.K) 16.70 Btu/ft h°F

在20 °C 變化至目標溫度的熱膨脹 / *Thermal expansion between 20 °C (68 °F) and ... °C (°F)*							
20 °C	100 °C	200 °C	300 °C	400 °C	500 °C	600 °C	
–	11,45	11,95	12,34	12,69	13,04	13,31	10^{-6} m/(m.K)
68 °F	212 °F	392 °F	572 °F	752 °F	932 °F	1112 °F	
–	6.36	6.64	6.86	7.05	7.24	7.39	10^{-6} in/in°F

熱傳導係數 / *Thermal conductivity*							
20 °C	100 °C	200 °C	300 °C	400 °C	500 °C	600 °C	
28,9	29,8	30,9	31,0	30,7	30,3	29,7	W/(m.K)
68 °F	212 °F	392 °F	572 °F	752 °F	932 °F	1112 °F	
16.70	17.22	17.85	17.91	17.74	17.51	17.16	Btu/ft h°F

若有本目錄未提到之產品應用或加工過程，請與我們聯絡，我們將就個案提供您專業材料使用之建議

Regarding applications and processing steps that are not expressly mentioned in this product description/data sheet, the customer shall in each individual case be required to ***consult us.***

BEARBEITUNGSHINWEISE
MACHINING RECOMMENDATIONS

加工性 / *Machinability*	
軟退火 / *Soft annealed*	
車削/ *Turning*	
工具 / *Tool*	Böhlerit PWLN 2525 M08 / WNMG 060408-BM LC225K
加工速度 / *Speed* v_c (m/min)	130
進給速度 / *Feed* f (mm/U)	0,40
粗銑 / *Rough milling* (Ø 25 R 3,5 mm)	
工具 / *Tool*	Depo M40 NTV Atorn RDHW 0702 MOS
加工速度 / *Speed* v_c (m/min)	150 – 240
進給速度 (mm/齒) / *Feed* f_z (mm/tooth)	0,40
加工深度 (mm) / *Depth of cut* a_p (mm)	0,50
加工寬度 (mm) / *Width of cut* a_e (mm)	17,50
鑽孔 / *Drilling* (Ø 6,8 mm)	
工具 / *Tool*	Titex VHM Bohrer A3389DPL-6.8
加工速度 / *Speed* v_c (m/min)	225
進給速度 / *Feed* f (mm/U)	0,18
深孔鑽削/ *Deep-hole drilling* (Ø 8 mm)	
工具 / *Tool*	Botek 8x350 K15B Hammond GM08000 A0320 EFHM (Einlippenbohrer / *Gun Drill*)
加工速度 / *Speed* v_c (m/min)	100
進給速度 / *Feed* f (mm/U)	0,04

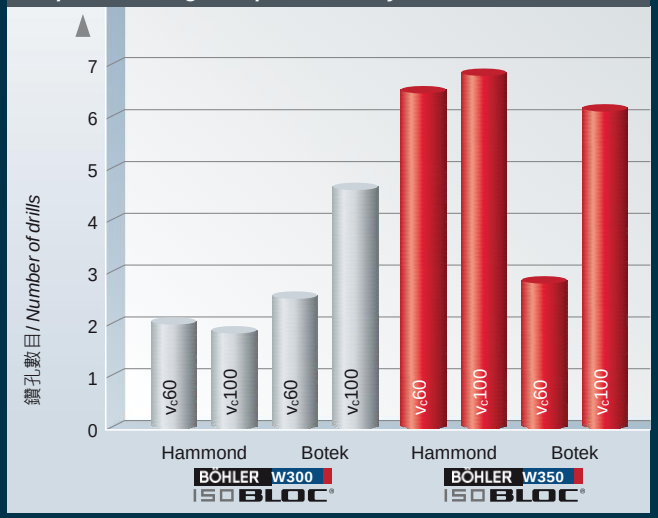
加工性 / *Machinability*	
軟退火 / *Soft annealed*	
攻絲 / *Tapping* M8	
工具 / *Tool*	Franken-Emuge B05037000080MGB
加工速度 / *Speed* v_c (m/min)	24

回火預硬 / *Hardened and Tempered*	
預精加工 / *Pre-finishing* (Ø 12 R 5 mm)	
工具 / *Tool*	Böhlerit-Kieninger WPB 12-FB-50 LC610Z
加工速度 / *Speed* v_c (m/min)	290 – 385
進給速度 (mm/齒) / *Feed* f_z (mm/tooth)	0,13 – 0,18
加工深度 (mm) / *Depth of cut* a_p (mm)	0,27
加工寬度 (mm) / *Width of cut* a_e (mm)	1,50
精加工 / *Finishing* (Ø 8 mm)	
工具 / *Tool*	Franken-Emuge 1966A.008
加工速度 / *Speed* v_c (m/min)	750 – 1250
進給速度 (mm/Zahn) / *Feed* f_z (mm/tooth)	0,05
加工深度 (mm) / *Depth of cut* a_p (mm)	0,20
加工寬度 (mm) / *Width of cut* a_e (mm)	0,20

從比較性實驗之結果可見，在對BÖHLERW350進行鑽深孔之加工時，尤其是在高切削速度下，可以鑽出更多的孔。

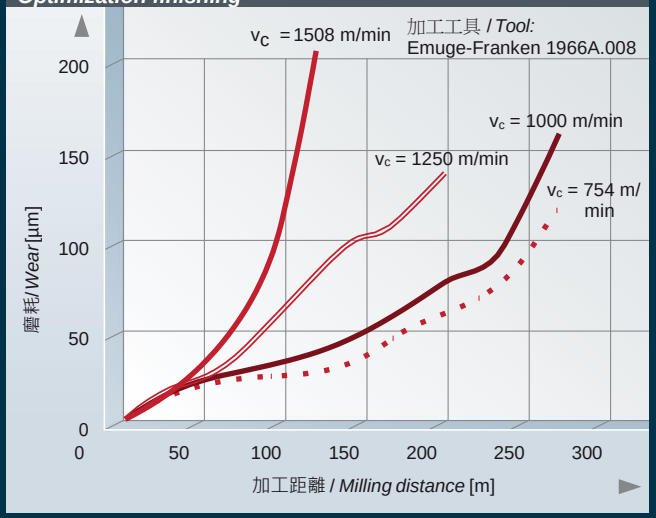
The comparative study shows that at deep-hole drilling of BÖHLER W350 espacially at higher cutting speed a higher number of drills could be realized.

深孔鑽削比較測試 /
Deep-hole drilling: comparative study



為了優化BÖHLERW350精加工的步驟，使用不同切割速度和刀具進行測試。 結果證明，刀具壽命隨著切削速度的增加而降低

最佳化精加工/
Optimization finishing



To optimize the finishing process BÖHLER W350 was tested at different cutting speed and tools. It has shown that the milling distance decreases with increasing cutting speed.

BÖHLER

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