BÖHLER

冷作工具鋼

COLD WORK TOOL STEEL

BÖHLER K490

MICROCLEAN®

使用粉末冶金技術製造之全方位冷作工具鋼
OUR COLD WORK TOOL STEEL PRODUCED BY POWDER METALLURY: THE ALL-ROUNDER

創新

百樂鋼之冷作鋼系列新鋼種 K490 MICROCLEAN 滿足了業界對兼顧耐磨性以及韌性之鋼種需求

靈活性

擁有最新科技的 BOHLER 鋼廠製造之粉末冶金鋼種具有加工性佳、以及熱處理靈活性較大等優勢，可調整部分熱處理參數但不影響其機械性能。

降低成本

這些出色的特性使工具製程風險降低、靈活性高且速度快，進而降低生產成本

多功能性

百樂鋼 K490 MICROCLEAN 更為先進並有效率，與其他粉末冶金製程之冷作鋼材質相比(如 M4、 PM23 等)，**在相同耐磨性條件之下，韌性可達雙倍以上**

Innovation

BÖHLER's new cold work tool steel K490 MICROCLEAN closes the gap in the material demands between wear resistance and the desired high toughness.

Flexibility

A further advantage of this powder metallurgical cold work tool steel, being produced in a plant of the newest generation, lies in the good machinability and the high flexibility of its heat treatment, which allows variable heat treatment cycles without affecting the mechanical properties.

Cost-efficiency

These excellent properties guarantee tool manufacturing that is risk-free, more flexible, faster and more economical.

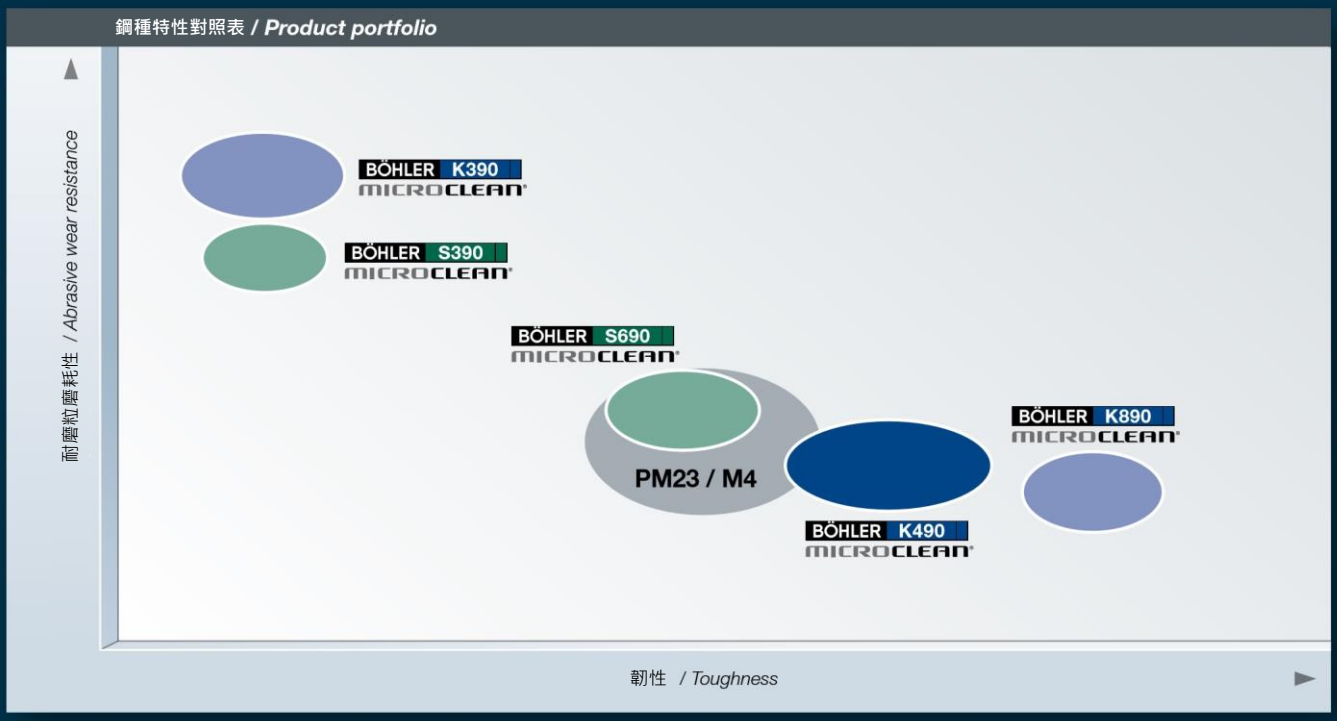
Versatility

BÖHLER's K490 MICROCLEAN is a greatly improved and more efficient cold work tool steel compared with other commonly used PM steels such as M4 or PM23. Toughness is more than doubled with a similar wear resistance.

合金成分 (百分比 %) / *Chemical composition (average %)*					
C	**Cr**	**Mo**	**V**	**W**	**andere / *others***
1,40	6,40	1,50	3,70	3,50	+Nb

總結: **簡單、快速、多功能**等特性能可提升
獲利力、效率以及生產力

In short: ***Simple, fast, versatile*** *equals*
profitable, efficient, productive.



百樂鋼 K490 MICROCLEAN: 集結各項出色性能之最佳選擇

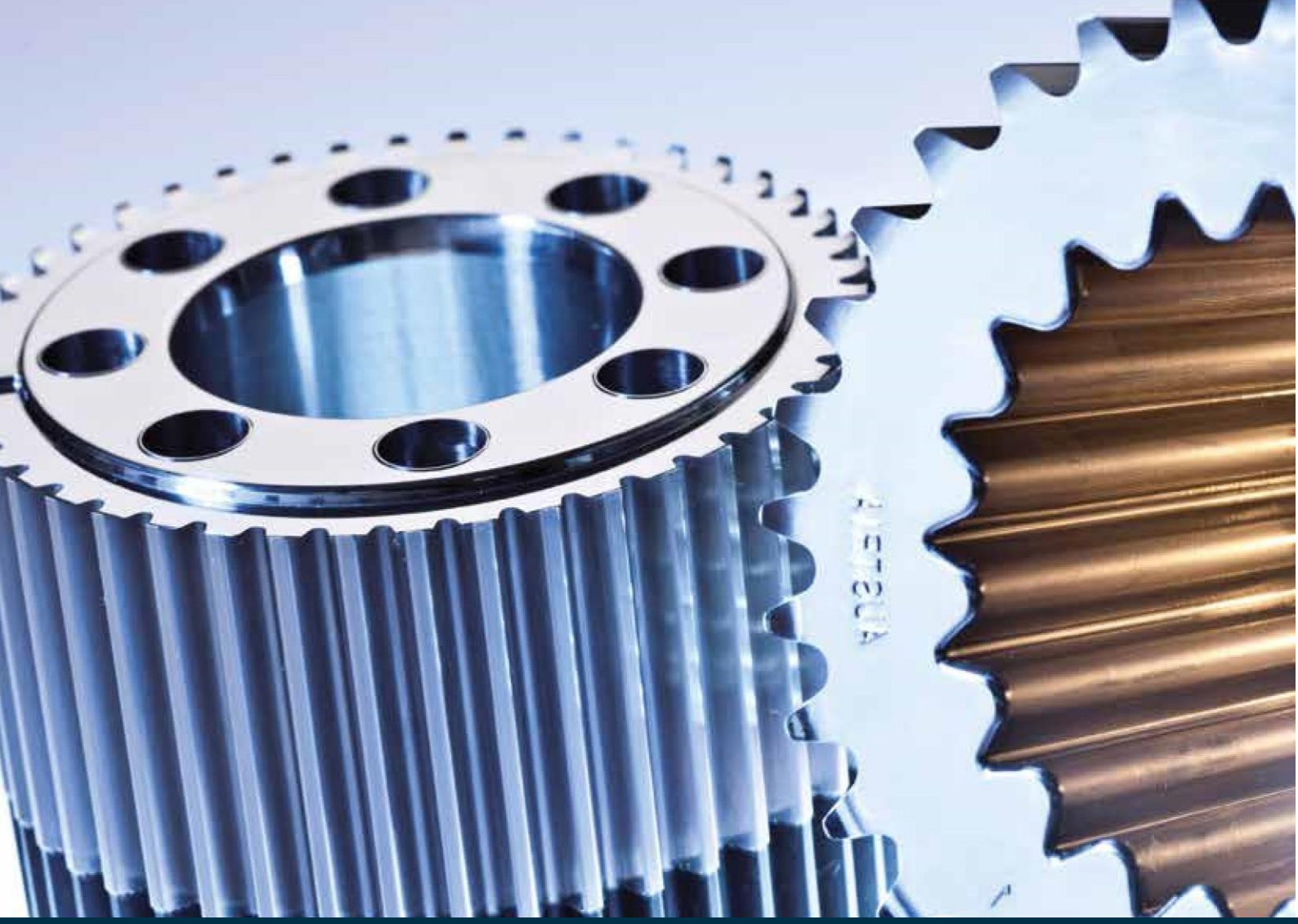
THE BEST IS THE SUM OF OUTSTANDING PROPERTIES: BÖHLER K490 MICROCLEAN

特性

- 高硬度 (可達 64 HRC)
- 韌性優異
- 高耐磨耗性 (包含磨粒磨耗及黏著磨耗)
- 硬加工性極佳
- 高抗壓強度
- 能與一般等級之冷作鋼(2379/D2)一起進行熱處理，淬火溫度範圍自 1030 至 1080 °C
- 穩定之機械性質

Properties

- *High hardness (up to 64 HRC)*
- *Very good toughness*
- *High abrasive and adhesive wear resistance*
- *Excellent hard machinability*
- *High compressive strength*
- *Heat treatment together with common cold work tool steels (1.2379, D2) at hardening temperatures from 1030 to 1080 °C (1885 – 1980 °F) possible*
- *Stable mechanical properties*



百樂鋼 K490 MICROCLEAN 為工具製造者帶來之益處

- 得益於靈活性較高之熱處理參數及出色的硬加工性，使工具製造者能使用更短且更便宜之製程

Benefits of BÖHLER K490 MICROCLEAN for the tool maker

- *Shorter and cheaper production processes due to flexible heat treatment and excellent hard machinability.*

百樂鋼 K490 MICROCLEAN 為工具使用者帶來之益處

- 優異並穩定之機械性能得以提升工具壽命，進而**降低單位製造成本**

Benefits of BÖHLER K490 MICROCLEAN for the tool user

- *Increased tool life due to the excellent and stable mechanical properties –* ***resulting in a reduction in unit costs****.*

卓越製程帶來的進步

PROGRESS BASED ON SUPERIOR TECHNOLOGY

擁有世界最先進粉末製程之鋼廠

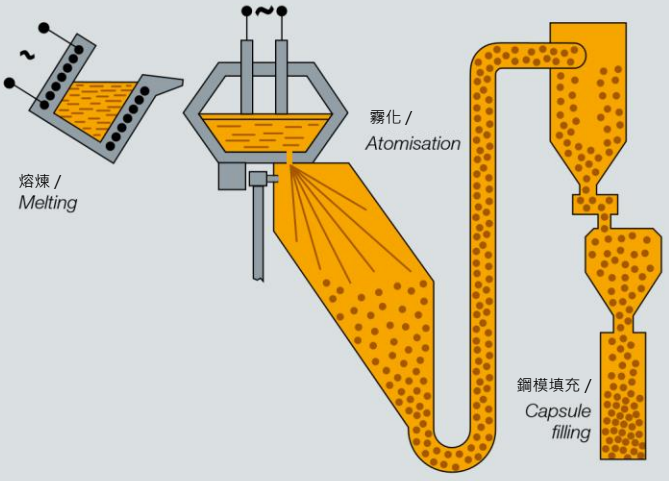
百樂第三代粉末冶金製造技術為粉末冶金業界製程之一大進步，其生產的粉末高性能高速鋼及工具鋼可提升工具的使用壽命達數倍之多。

百樂鋼 K490 MICROCLEAN 的優勢來自於其粉末冶金之製程以及新發展出之合金，使本鋼種擁有極細微並均勻分布之不同種類碳化物。這種新研發出的鋼種擁有**改善之韌性、較好之耐磨耗性和穩定之機械性質**。

The world's most modern PM steel production plant.

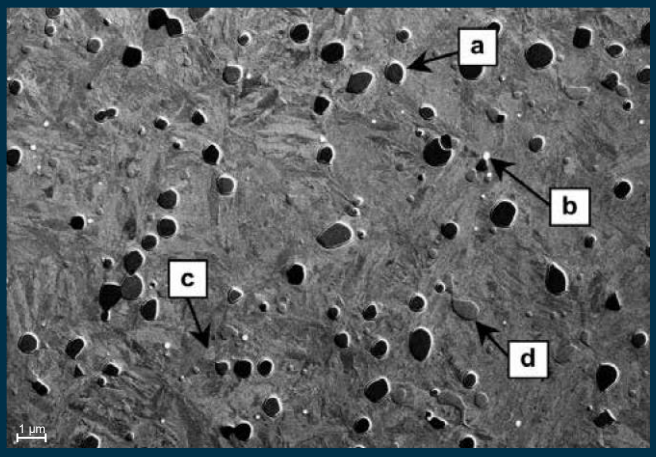
BÖHLER develops and produces high-performance PM-high speed steels and tool steels, which increase tool life time cycles several times over. We consider this to be a technological leap forward from BÖHLER: 3rd generation PM materials.

***BÖHLER K490 MICROCLEAN** owes its superior properties above all to the powder-metallurgical production process and the newly developed alloy which has a very fine and regularly distributed carbide microstructure with different carbide types. This new development made by BÖHLER results in **an improved toughness, an increased adhesive wear resistance and in stable mechanical properties**.*

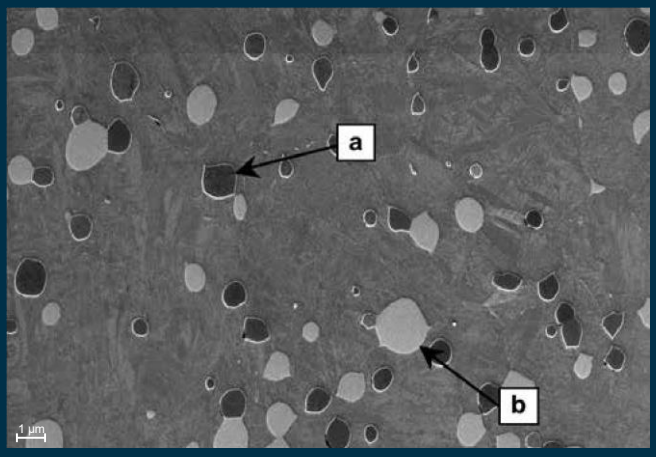


百樂鋼 K490 MICROCLEAN 與 PM23 之微觀組織比較

*Microstructure comparison of **BÖHLER K490 MICROCLEAN** with a PM23.*



BÖHLER K490 MICROCLEAN



PM23 Type

a = MC-type b = M_6C-type c = M_7C_3-type d = $M_{23}C_6$-type

經過最嚴苛之測試
TESTED FOR THE HIGHEST REQUIREMENTS

下表顯示使用碳化鎢和立方氮化硼 CBN 製成之可替換刀片，對在硬化狀態之下之 **BÖHLER K490 MICROCLEAN 進行加工之加工性比較**

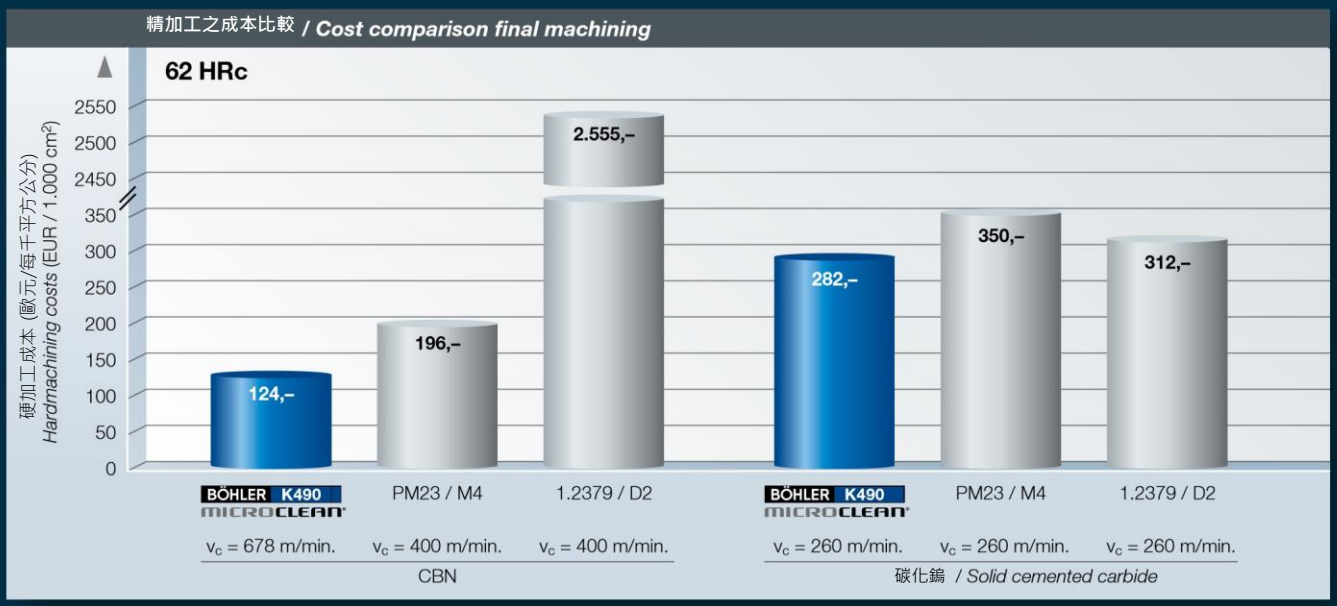
CBN 工具的優勢在於這些工具較長之壽命及較快之切削速度，但 CBN 材質之價格較碳化鎢更加昂貴，在評估工具成本時，這些優勢及劣勢都須納入評估範圍之內。

整體而言，BÖHLER K490 MICROCLEAN 相較其他粉末冶金鋼種或其他含 12%Cr 之傳統粒滴斑鐵鋼種，是一項**更加節省成本之解決方案**。

*The following diagram shows the results of **BÖHLER K490 MICROCLEAN's** machinability in a hardened and tempered condition by using tools with changing plates made of solid cemented carbide and cubic Bornitride CBN.*

***The advantages of these CBN tools** lie in their higher tool life and in higher cutting speeds in tool usage. CBN cutting materials, however, are more expensive than solid cemented carbide. The advantages and disadvantages were nevertheless taken into account in the evaluation of costs.*

***BÖHLER K490 MICROCLEAN** is, all in all, the **more cost-effective solution** when compared to other powder metallurgical and conventional ledeburitic 12% Cr steels.*



本測試在真實情境之加工實驗室中進行; 由 Profactor 公司進行

Tested under real conditions in the machining laboratory. Company: Profactor
CBN – Cutting plate: BN081 CBN
VHM – Solid cemented carbide cutting plate: LC610Z VHM

多功能使用之特性使其在多數產業均是最佳選擇
THE BEST ONES ARE THE VERSATILE ONES

BÖHLER K490 MICROCLEAN 平衡之特性得以用在廣泛應用之中，使其成為冷作鋼領域中真正的全方位粉末鋼種

沖孔與下料產業
- 用在一般沖壓下料或精密下料之切割工具 (模具, 沖頭)
- 輥刀

冷成形應用
- 擠型工具 (冷擠型或溫擠型)
- 引伸或深引伸工具
- 沖壓工具
- 牙板、牙輪
- 多輥機架之冷軋輥
- 冷成形軋管之心軸
- 製藥或陶瓷工業所用之粉末冶金模具
- 用於燒結零件之粉末冶金模具

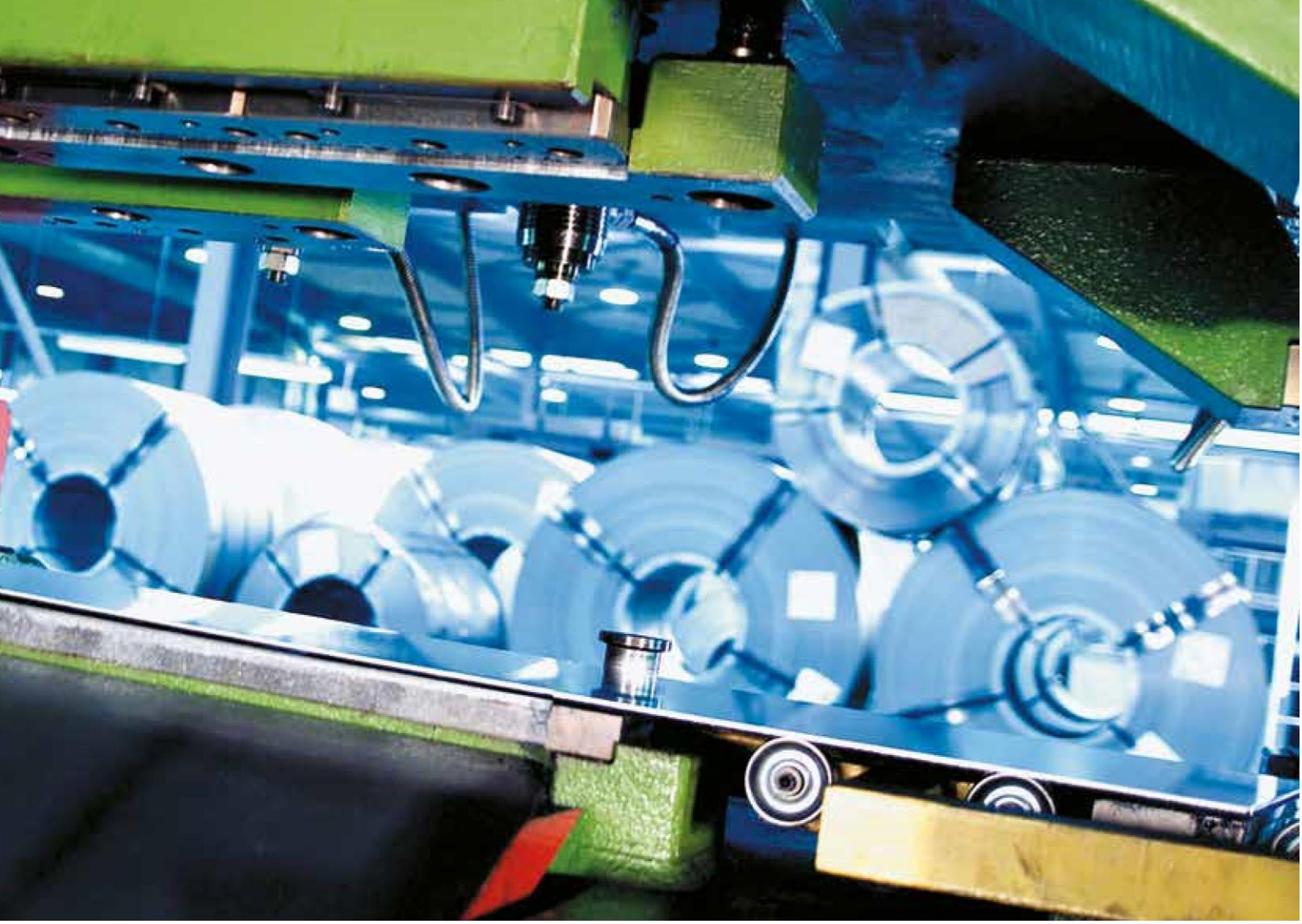
- **工業用刀**
- **塑膠加工產業**

***BÖHLER K490 MICROCLEAN**'s balanced properties can be made use of in a wide range of applications, making it a real PM all-rounder for cold work tool steel applications.*

Blanking and punching industry
- *Cutting tools (dies, punches) for normal and precision blanking*
- *Cutting rolls*

Cold forming applications
- *Extrusion tooling (cold and warm forming)*
- *Drawing and deep-drawing tools*
- *Stamping tools*
- *Thread rolling tools*
- *Cold rolls for multiple roller stands*
- *Cold pilger rolling mandrels*
- *Compression moulding dies for the ceramics and pharmaceutical industries*
- *Compression moulding dies for the processing of sintered parts*

- ***Industrial knives***
- ***Plastics processing industry***



物理特性 [1] / *Physical properties [1]*	
條件: 已預硬並回火/ *Condition: hardened and tempered*	
20 °C 下之彈性模數 / *Modulus of elasticity at 20 °C* *Modulus of elasticity at 68 °F*	223 GPa 32.3 x 10^3 ksi
20 °C 下之密度 / *Density at 20 °C* *Density at 68 °F*	7,79 kg/dm^3 0.281 lbs/in^3
20 °C 下之電阻率/ *Electrical resistivity at 20 °C* *Electrical resistivity at 68 °F*	0,55 Ohm.mm^2/m 331 Ohm circular-mil per ft
20 °C 下之比熱容量/ *Specific heat capacity at 20 °C* *Specific heat capacity at 68 °F*	450 J/(kg.K) 0.107 Btu/lb °F
20 °C 熱傳導係數 / *Thermal conductivity at 20 °C* *Thermal conductivity at 68 °F*	19,6 W/(m.K) 11.3 Btu/ft h °F

[1] 來源 / *Source* : Materials Center Leoben Forschung GmbH, ÖGI

自 100 °C 至 °C 之熱膨脹係數/ *Thermal expansion between 100 °C (210 °F) and ... °C (°F)*							
100 °C	200 °C	300 °C	400 °C	500 °C	600 °C	700 °C	
10,6	11,1	11,6	11,9	12,3	12,6	12,8	10^{-6} m/(m.K)
210 °F	390 °F	570 °F	750 °F	930 °F	1110 °F	1290 °F	
5.89	6.17	6.44	6.61	6.83	7.00	7.11	10^{-6} in/in °F

針對本目錄中未提及之應用與使用方式，請與我們聯絡
我們將就個案提供您專業之材料使用建議

The customer will be required to ***consult with us*** *on an individual basis regarding applications and processing steps that are not expressly mentioned in this product description/data sheet.*

最好地整合看似矛盾的特性
THE BEST UNITE EVEN SEEMINGLY OBVIOUS CONTRADICTIONS

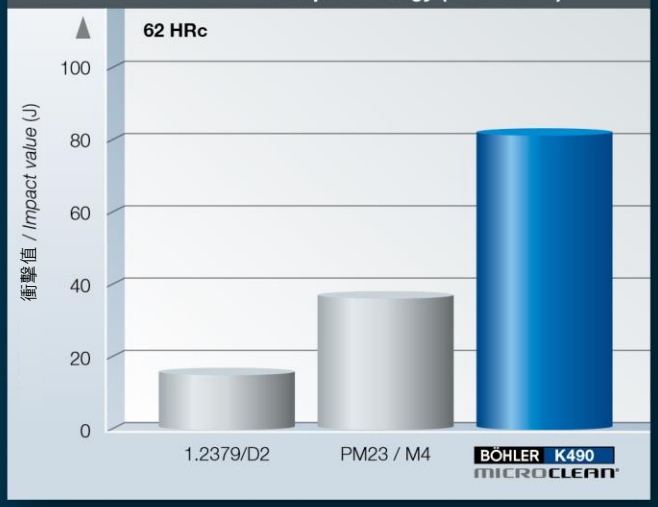
與常見用於冷作工具之粉末工具鋼相比，**百樂鋼 K490 MICROCLEAN** 憑藉著相同之耐磨性和**超過其他鋼種一倍以上之韌性**，得以在性能上出類拔萃。另外，較佳的可變型性更能避免意外損壞。

以上所提之特性均能提高工具壽命。

*Compared with commonly used PM alloys in cold work tool steel applications, K490 MICROCLEAN excels with its consistent wear resistance coupled with a more than **doubled toughness**. In addition, the higher deformability provides increased security against unforeseeable breakage.*

All of these properties result in a longer tool life.

衝擊能量 (無缺口) / *Impact energy (unnotched)*



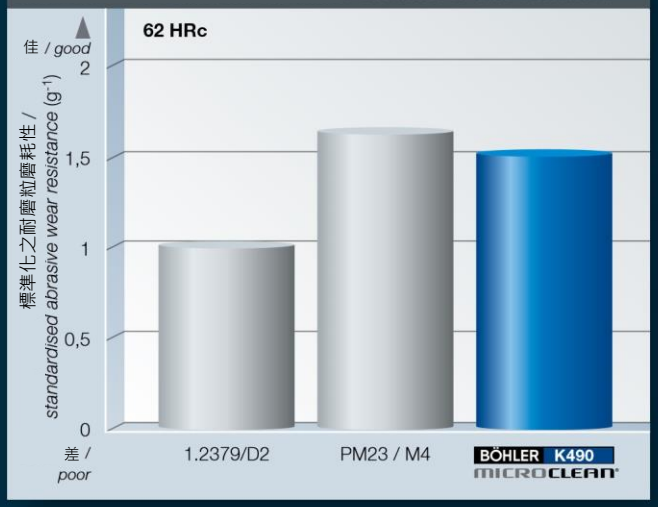
從輥軋製之鋼板上縱向取試片，以 λ ≤ 0.5 之冷卻速率進行熱處理
Samples taken from a rolled steel bar in longitudinal direction, heat treated at a cooling rate of: λ ≤ 0,5

測試之材料原尺寸 / *Primary material size*: 圓棒 / *round* 35 mm

試片尺寸 / *Sample size*: 10 x 7 x 55 mm

試片之熱處理參數 / *Heat treatment parameters for*:
BÖHLER K490 MICROCLEAN: 1080 °C (1980 °F), 3 x 2 h, 560 °C (1040 °F)
PM23: 1100 °C (2012 °F), 3 x 2 h, 570 °C (1058 °F)
1.2379/D2: 1070 °C (1958 °F), 3 x 2 h, 520 °C (968 °F)

耐磨粒磨耗性 / *Abrasive wear resistance*



數據由依照 ASTM G65 規範下執行之乾沙橡膠輪測試結果得出 / *Determined by the rubber disc dry sand test according to ASTM G65*

從輥軋製之鋼板中心橫向取試片 / *Samples taken from a rolled steel bar in lateral direction, center*

測試之材料原尺寸 / *Primary material size*: 圓棒 / *round* 70 mm

試片尺寸 / *Sample size*: 60 x 25 x 8 mm, Ra < 0,8 µm

試片之熱處理參數 / *Heat treatment parameters for*:
BÖHLER K490 MICROCLEAN: 1080 °C (1980 °F), 3 x 2 h, 560 °C (1040 °F)
PM23: 1130 °C (2066 °F), 3 x 2 h, 590 °C (1094 °F)
1.2379/D2: 1070 °C (1958 °F), 3 x 2 h, 510 °C (968 °F)

正確的熱處理將得到最佳化之結果
THE RIGHT HEAT TREATMENT MEANS OPTIMUM RESULTS

出廠硬度
- 軟退火至最高 280HB

應力消除
- 650 至 700 °C 之間
- 心部溫度到達後，在正常大氣壓中放置 1-2 個小時
- 在爐中緩慢降溫

淬火
- 1030 至 1080 °C 之間/油淬, 氮氣淬火
- 遵照以下溫度充分加熱:
  1030 至 1080 °C 之間加熱 20 至 30 分鐘
- 針對淬火溫度若需進一步之協助請與我們聯絡

回火
- 需在淬火後立即執行，緩慢加熱至回火溫度
- 爐中時間計算方式: 每 20 mm 厚度加一小時，但需回火至少兩小時
- 在空氣中冷卻
- 建議回火至少三次
- 硬度可達 58 至 64 HRC

Delivery condition
- *soft annealed max. 280HB*

Stress relieving
- *650 to 700 °C (1200 – 1290 °F)*
- *After through-heating, soak for 1 to 2 hours in a neutral atmosphere.*
- *Cool slowly in furnace.*

Hardening
- *1030 to 1080 °C (1885 – 1980 °F)/oil, N 2*
- *Following temperature equalisation:*
  20 – 30 minutes for a hardening temperature of 1030 – 1080 °C (1885 – 1980 °F)
- *For additional hardening temperatures please consult us.*

Tempering
- *Slowly heat to tempering temperature immediately after hardening.*
- *Time in furnace: 1 hour for every 20 mm (0.79 inch) of workpiece thickness but at least 2 hours.*
- *Cool in air.*
- *We recommend that the steel be tempered at least 3 times.*
- *Obtainable hardness: 58 – 64 HRC*

表面處理

- 適用於鹽浴，氣體和離子氮化以及任何常規使用的 PVD 鍍模

焊補

與多數工具鋼一樣，在焊接過程中通常伴隨著開裂的風險。若您有必須焊接之需求，請務必遵循您的焊接材料 (焊條或焊藥) 製造商之指示及建議進行

若需進一步之銲接資訊，請參考百樂鋼廠關於工具鋼銲接之型錄

Surface treatment

- *Suitable for salt bath, gas and plasma nitriding and for any conventionally used PVD coatings*

Repair welding

There is a general risk of cracking during welding as is the case with tool steels. Should there be a need for welding we ask you to follow the guidelines of your manufacturer of weld consumables.

For further information please ask for our "Welding in Tool Making" leaflet.

為達到最佳結果之熱處理建議

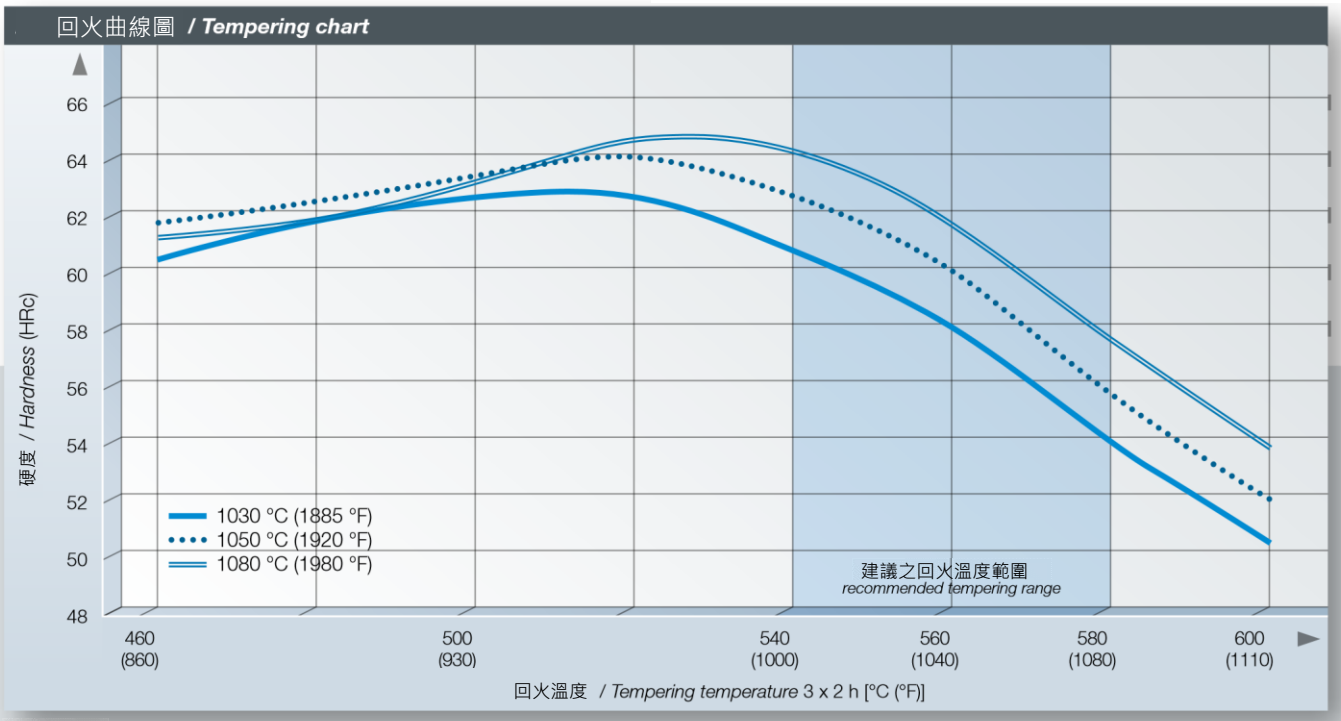
HEAT TREATMENT RECOMMENDATIONS FOR OPTIMUM RESULTS

百樂鋼 K490 MICROCLEAN 之獨特之處在於其熱處理的靈活性：

- 可以使用與常見冷作工具鋼相同的淬火溫度(例如:1.2379/D2)
- 淬火溫度只要介於 1030 – 1080 °C 之間均具有穩定的機械性質

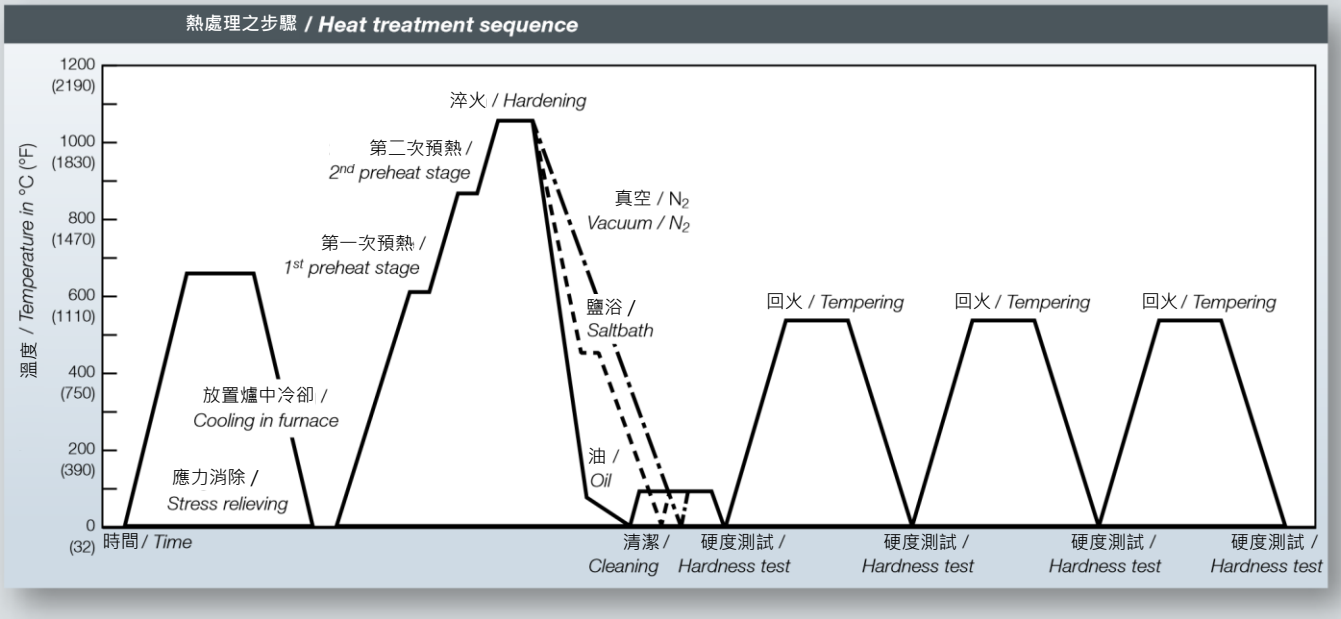
One of the remarkable features of BÖHLER K490 MICROCLEAN is its flexibility in heat treatment:

- *We recommend the same hardening temperatures as with widely used cold work tool steels (e.g. 1.2379/D2)*
- *Very stable mechanical properties, regardless of the hardening temperature (1030 – 1080 °C [1885 – 1980 °F])*



試片尺寸: 圓棒 35 x 15 mm

Sample size: round 35 x 15 mm



連續冷卻 CCT 曲線圖 / *Continuous cooling CCT curves*

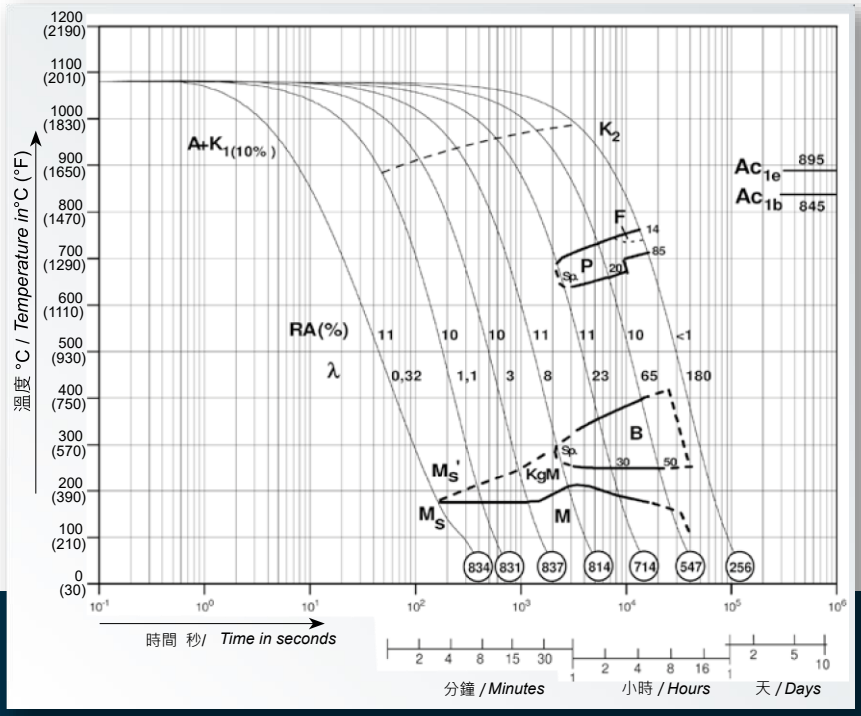
沃斯田鐵化溫度 : 1080 °C
持溫時間: 30 分鐘

λ = 0,32 … 180　冷卻參數, 例如: 自 800 冷卻至 500 ° C 所需之時間(s x 10^{-2})

Austenitizing temperature: 1080 °C (1980 °F)
Holding time: 30 minutes

λ = *0.32 … 180 cooling parameter, i.e. duration of cooling from 800 – 500° C (1470 – 930 °F) in s x10^{-2}*

試片 / *Sample*	λ	HV_{10}
a	0,32	834
b	1,10	831
c	3,00	837
d	8,00	814
e	23,00	714
f	65,00	547
g	180,00	256

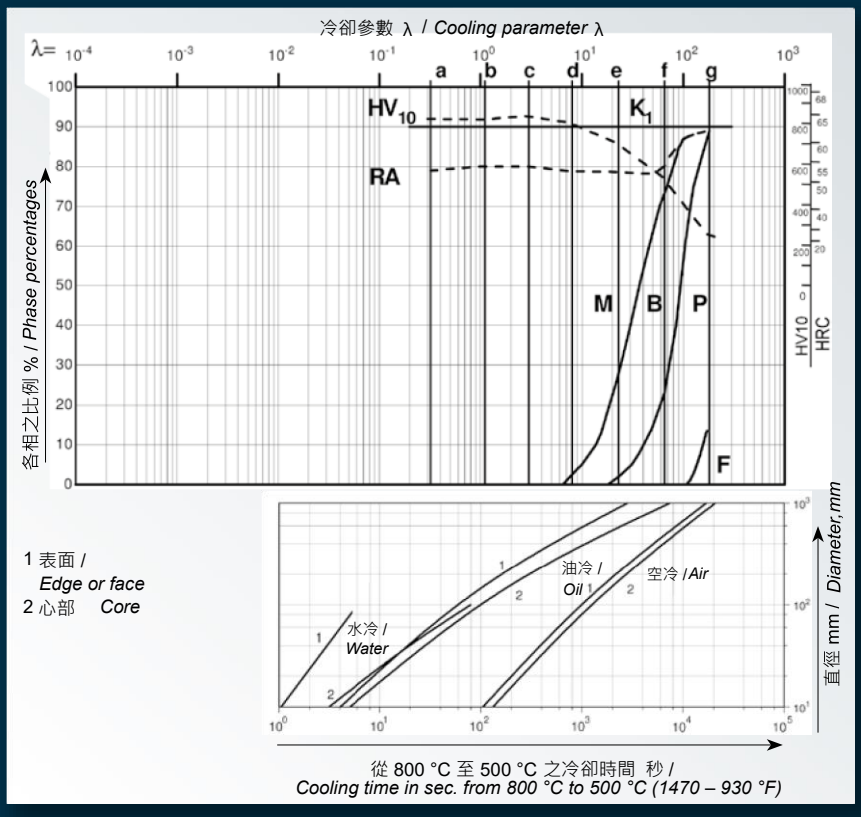


定量之相平衡圖 / *Quantitative phase diagram*

K1　沃斯田鐵化過程中未溶解的碳化物部分 (10%) / *carbides which are not dissolved during austenitization (10%)*

K2　自沃斯田鐵化溫度開始冷卻之時，碳化物同時開始析出 / *start of carbide precipitation during quenching from austenitizing temperature*

LK　粒滴斑鐵 / *Ledeburitic carbides*
RA　殘留沃斯田鐵 / *Retained austenite*
A　沃斯田鐵 / *Austenite*
M　麻田散鐵 / *Martensite*
P　波來鐵 / *Perlite*
B　變韌鐵 / *Bainite*
F　肥粒鐵 / *Ferrite*



成功的基礎:
加工準則

THE BASIS FOR SUCCESS:
MACHINING GUIDELINES

在退火狀態下使用碳化鎢車削 ***Turning with cemented carbide in annealed condition***

加工方式 / *Type of machining*	粗加工 / *Rough machining*	一般加工 / *Normal machining*	精加工 / *Final machining*
加工深度 (mm) / *Depth of cut (inches)*	2 – 5 (.08 – .2)	1 – 3 (.04 – .12)	0,2 – 0,3 (.008 – .012)
每轉進給量 (mm/轉) / *Feed mm/rev. (inches/rev.)*	0,3 – 0,8 (.012 – .032)	0,2 – 0,4 (.008 – .016)	0,15 – 0,25 (.006 – .01)
BOEHLERIT-刀具牌號 / *BOEHLERIT carbide grade*	LC 215K	LC 215H, LC 610H	LCM 205
ISO-牌號 / *ISO carbide grade*	P15	P15, K10	
加工速度 v_c (m/min) / *Cutting speed v_c m/min (f.p.m)*	80 – 120 (260 – 390)	150 – 220 (490 – 740)	100 – 170 (330 – 560)

淬火及回火後進行加工 (58 – 64 HRc) ***Machining in hardened and tempered condition (58 – 64 HRc)***

粗加工 / *Rough machining*	**CBN**	**碳化鎢 / *Solid Cemented Carbide***
加工速度 v_c (m/min) / *Cutting speed v_c m/min (f.p.m)*	300 (985)	220 (740)
進給 mm/每齒 / *Feed mm/tooth (inches/tooth)*	0,17 (.0068)	0,17 (.0068)
精加工 / *Final machining*	**CBN**	**碳化鎢 / *Solid Cemented Carbide***
加工速度 v_c (m/min) / *Cutting speed v_c m/min (f.p.m)*	678 (2270)	260 (850)
進給 mm/每齒 / *Feed mm/tooth (inches/tooth)*	0,2 (.008)	0,2 (.008)

CBN – 加工刀片 / *Cutting plate* : BN081 CBN
VHM – 加工刀片 / *Cutting plate* : LC610Z VHM

研磨 *Grinding*

狀態/ *Condition*	空心圓 外圓研磨 / *External grinding*	空心圓 內圓研磨 *Internal grinding*	無心研磨/ *Centerless*		平面研磨/ *Flat grinding*	成形研磨 / 深磨 / *Profile / deep grinding*
軟退火 / *soft annealed*	57A80 H8V300W	54A80 H15VPMF904W	橫向式 / *Surface* 直向式/ *Plunging*	54A80 J7V904W 54A120 J7V904W	54A60 H15VPMF904W	54A80 H15VPMF904W
淬火及回火 / *hardened and tempered* < 62HRc	93N80 H8V601W	93A80 H13VP601	橫向式 / *Surface* 直向式 / *Plunging*	93A80 J7V601W 93A120 J7V601W	64A60 H15VP300W	93A80 F15VPH601W 54A80 F15VPH904W
淬火及回火 / *hardened and tempered* > 62HRc	32B91 P5V600C100 ev. 93A80 H8V601W	32B91 P8CV600C100	橫向式 / *Surface* 直向式 / *Plunging*	32B126 P8CV600C100 32B126 N5CV800C100	93A60 F15VPH601W 32B126 Q15CVPMF600C75	93A80 F15VPH601W

沙輪品質 / *Quality of discs*: 93N... Nanowin, 適用於軟合金之零件/*Nanowin, suitable for soft alloys*
93A... 燒結氧化鋁以及白色氧化鋁之混合 / *Blend of sintered corundum + white corundum*
54A... 具再結晶鍵體之白色氧化鋁 / *White corundum, with a re-crystalline bonding system*
57A... 結晶較 54A 更強韌之粉色氧化鋁 / *Pink corundum, grain is somewhat tougher than 54A*
64A... 單晶氧化鋁及粉色氧化鋁之混合 / *Monocrystal corundum – pink corundum blend*
32B... 立方氮化硼 (CBN) / *Cubic Bornitrite (CBN)*

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