BÖHLER

KALTARBEITSSTAHL
COLD WORK TOOL STEEL

BÖHLER K390 MICROCLEAN®

冷作工具钢
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Bindungsteile / 固定器

BÖHLER K390 MICROCLEAN
是完全由粉末冶金方法制备的冷作工具钢，并且是BOHLER公司产品中具有最佳性能的冷作模具钢。

此钢材可满足高耐磨损性与高抗压强度的要求。

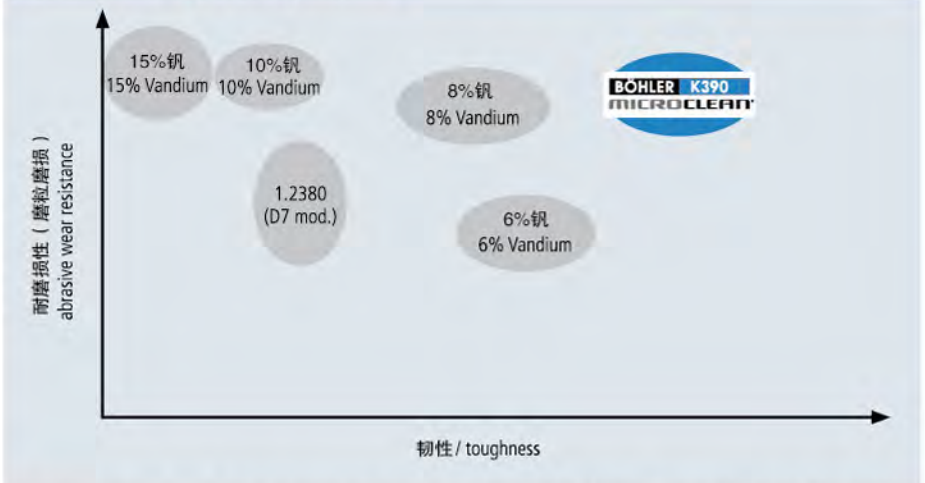
- 适用于**剪切，下料，冲孔**。
- 适用于**冷成型**。
- 与**塑料加工产业**。

BOHLER K390 MICROCLEAN is quite simply the powder metallurgical cold work tool steel with the best properties for cold work applications currently available from BÖHLER.

This steel was developed to meet the high demands required of the wear resistance and compressive strength

- in **cutting, blanking and punching applications**,
- in **cold forming applications**,
- and in the **plastics processing industry**.

Produktplazierung / Product placement



由铬、钨、钼、钒所形成的合金碳化物与基体的完美结合，为钢材提供了优良的耐磨损性与韧性。

The carbide-forming elements Cr, W, Mo and V in combination with the optimised matrix are responsible for the optimal combination of abrasive wear resistance and toughness.

用数据说话
THE FIGURES SPEAK FOR THEMSELVES

BOHLER K390 MICROCLEAN降低成本的3大因素:

- 极佳的耐磨损性
- 出色的韧性
- 高抗压强度

3 factors contribute to the cost efficiency of BÖHLER K390 MICROCLEAN:

- an extremely high wear resistance
- outstanding toughness
- high compressive strength

化学成份（平均值%）/ Chemical composition (average %)							
C	Si	Mn	Cr	Mo	V	W	Co
2.47	0.55	0.40	4.20	3.80	9.00	1.00	2.00

由实验室到客户端

BOHLER了解到经济效益是钢材开发过程中的中心思想，由于BOHLER K390 MICROCLEAN优异的耐磨损性，高抗压强度及良好的韧性，使模具寿命增加数倍，这些材料特性，使客户可以更有效率的生产产品并同时降低每个成品的生产成本。

From laboratory to customer

BÖHLER recognises that the cost effectiveness of tooling is a central concern during the development process. Tool life can be increased by several hundred percent due to the outstanding wear resistance, high compressive strength and good toughness of BÖHLER K390 MICROCLEAN. These material properties enable our customers to make their production processes more efficient and consequently to reduce the price per part produced.

物理性能 1) / Physical properties 1)	
状态：淬硬+回火 / Condition: hardened and tempered	
弹性模量在 20 °C / Modulus of elasticity at 20 °C	220 x 10^3 N/mm²
Modulus of elasticity at 68 °F	32.0 x 10^6 psi
密度在 20 °C / Density at 20 °C	7,51 kg/dm³
Density at 68 °F	0.271 lbs/in³
电阻率在 20 °C / Electrical resistivity at 20 °C	0,59 Ohm.mm²/m
Electrical resistivity at 68 °F	355 Ohm circular-mil per ft
比热在 20 °C / Specific heat capacity at 20 °C	464 J/(kg.K)
Specific heat capacity at 68 °F	0.111 Btu/lb°F
热传导系数在 20 °C / Thermal conductivity at 20 °C	20,1 W/(m.K)
Thermal conductivity at 68 °F	11.61 Btu/ft h°F

热膨胀系数于 20 °C 与 ... °C Thermal expansion between 20 °C (68 °F) and ... °C (°F)							
100 °C	200 °C	300 °C	400 °C	500 °C	600 °C	700 °C	
12,2	12,5	13,0	13,2	13,7	14,0	13,7	10^{-6} m/(m.K)
210 °F	390 °F	570 °F	750 °F	930 °F	1110 °F	1290 °F	
6.78	6.94	7.22	7.33	7.61	7.78	7.61	10^{-6} in/in°F

1) 实测值

1) measured values

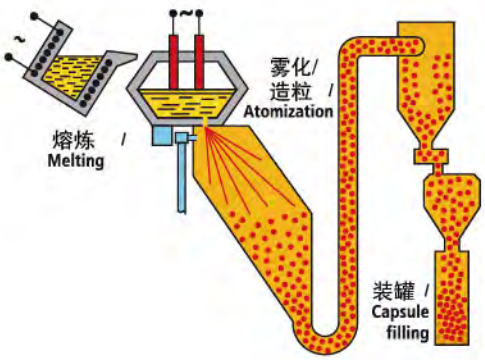
本产品说明书没有专门提及有关用途和加工手段的数据图表，用户可在个别咨询时提出要求。

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**.

BÖHLER K390 MICROCLEAN®

PM materials of the 3rd generation, for even better performance, are produced by BÖHLER in Kapfenberg in the most modern PM facility worldwide.

第三代粉末冶金技术生产的产品，有更佳的表现，在BOHLER位于Kapfenberg世界最先进的粉末冶金工厂制造。



BOHLER K390 MICROCLEAN拥有更好的特性是由于采用的粉末冶金制造工艺，BOHLER MICROCLEAN技术生产的钢材相较于传统冶炼的钢材，其优点有：

- 均匀细小的碳化物颗粒分布
- 由于改善的组织均匀性与无组织偏析而具有的各向同性

BÖHLER K390 MICROCLEAN owes its superior properties above all to the powder-metallurgical production process. The main advantages of BÖHLER MICROCLEAN steels over conventional steels are:

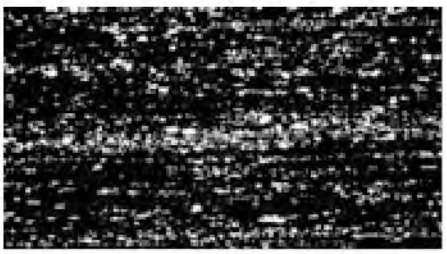
- uniform carbide distribution and small carbide size
- isotropic behaviour due to improved homogeneity and the absence of segregations

碳化物的尺寸与分布比较

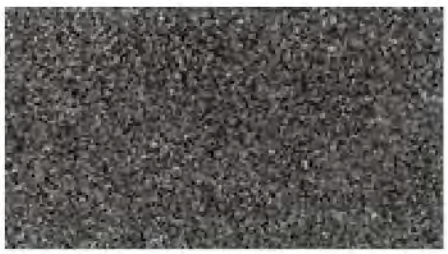
BOHLER K390 MICROCLEAN材料与传统冶炼的高碳12%铬工具钢的比较
（放大倍数 100x）

Comparison of carbide size and distribution

Comparison of **BÖHLER K390 MICROCLEAN** with a high carbon, 12% chromium steel produced by conventional methods (M = 100x)



12%铬钢 / 12% chromium steel (AISI D2)



BÖHLER K390 MICROCLEAN

冶炼技术一最好的机械性能
STATE-OF-THE-ART TECHNOLOGY – BEST PROPERTIES

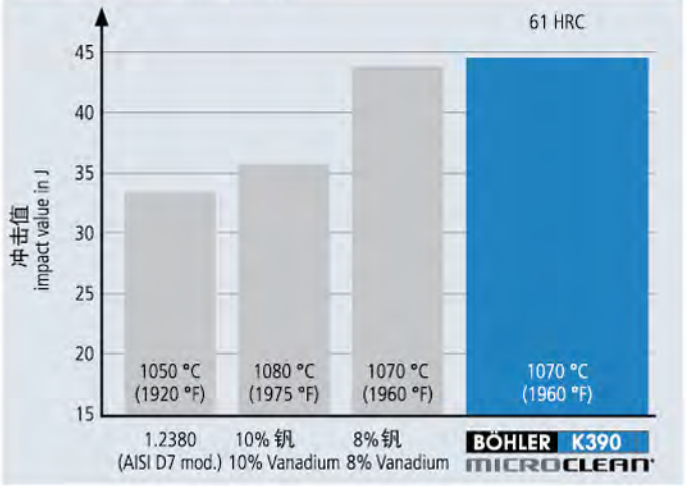
传统上，钢材的耐磨损性以增加钒含量来改善，因其可增加材料中MC碳化物的量。经过深入的研发工作，BOHLER发现通过优化基体结构亦可改善这一重要特性。

这表示BOHLER K390 MICROCLEAN拥有杰出的耐磨损性与韧性。因此可以在应用中避免开裂的情况下从而获得最大的安全性。

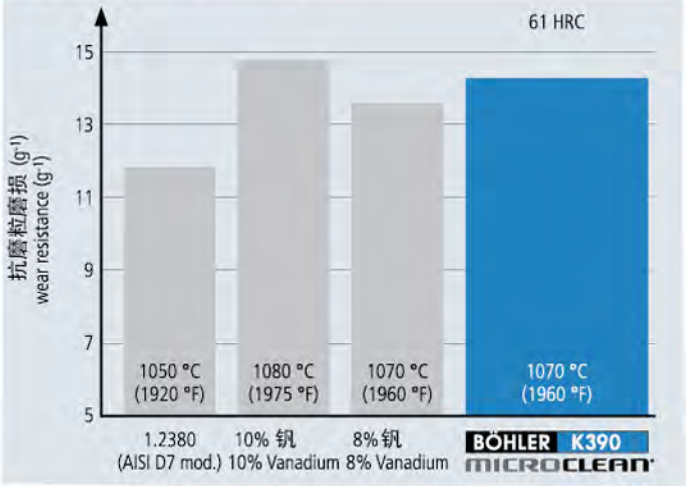
Traditionally, abrasive wear resistance has been increased by increasing the vanadium content of the steel and therefore increasing the amount of MC carbides in the material. Following years of intensive research and development work, BÖHLER has found an additional way of controlling this important property, by **optimising the matrix**.

This means that **BÖHLER K390 MICROCLEAN** is distinguished by its outstanding wear resistance and toughness. You can therefore count on a maximum safety against fracture under all operating conditions.

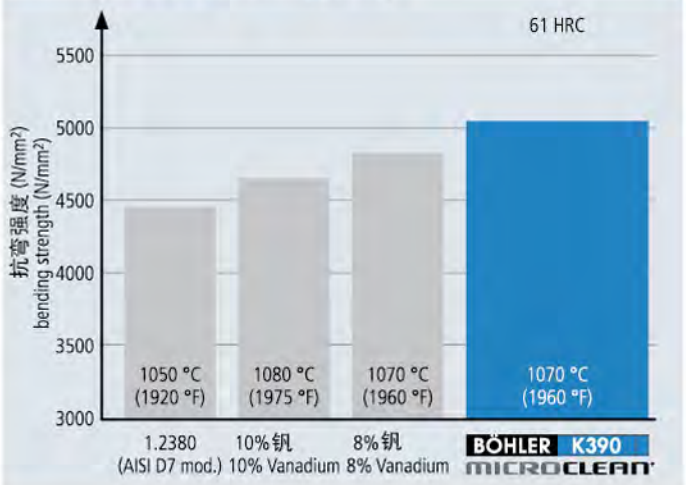
冲击韧性 / Impact energy



抗磨粒磨损 / Wear resistance



抗弯强度 / Bending strength



BÖHLER K390 MICROCLEAN®

突出的优点使粉末钢适用于各种不同领域:

下料与冲孔行业

- 冲切模（凹模，冲头）用于一般或精密下料
- 回转刀/滚切轮

冷成型

- 挤出模（冷或温加工成型）
- 拉深模具
- 冲压模
- 搓丝模
- 冷轧辊
- 冷轧管蕊
- 粉末压实模，陶瓷与制药工业
- 粉末压实模，制造烧结零件

刀具

- 裁纸与包装工业
- 丝切机的回转刀
- 回收产业的粉碎刀
- 薄板裁切刀

塑料加工业

- 塑料射出机套筒与螺杆
- 模具镶块
- 塑料射出喷嘴
- 逆止阀

The particular advantages of this PM steel make themselves felt in numerous 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.

Knives

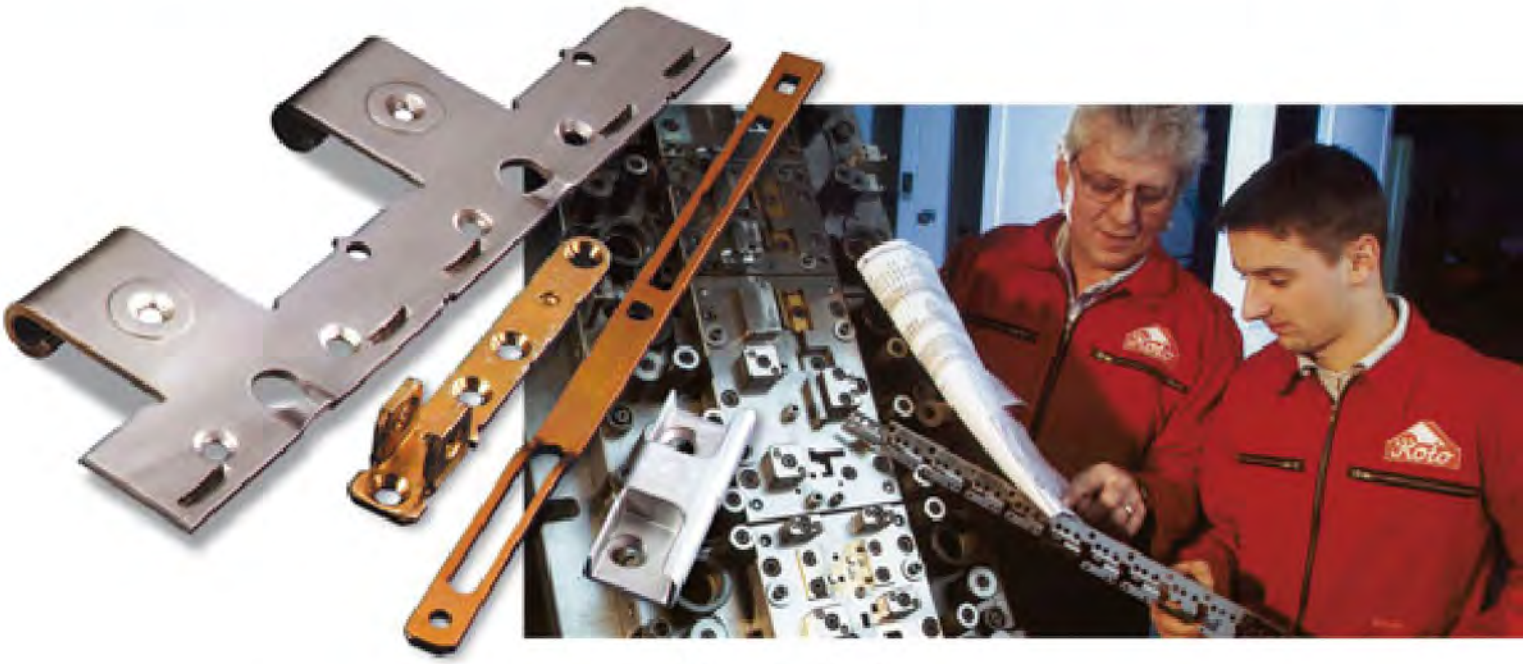
- Paper and packaging industries
- Circular knives for slitting machines
- Knives for the recycling industry
- Shearing blades for the cutting of thin sheet

Plastic processing industry

- Extruder cylinders and conveyor screws
- Mould inserts
- Injection nozzles
- Backflow valves

工件愈难制造一我们的钢材提供解决方案

BUSINESS IS GETTING HARDER – OUR STEEL HELPS



此材料易于加工是因为

- 各向同性的材料特性
- 最佳的研磨性一即使在模具型腔深处。
- 热处理的尺寸变化小。
- 淬火温度与保温时间有较大弹性。
- 容易放电加工，由于均匀分布的碳化物。

Easy handling during tool-making due to

- consistent materials properties over the whole cross-section and over the whole length for unproblematic machining
- best grindability – even in deep contours at the centre of the tool
- low and even dimensional change during heat treatment
- highly resilient against overheating or excessive time at temperatur during hardening
- easy electrical discharge machining due to the isotropic distribution of carbides

钢材使用者的益处

- 寿命增加。
- 降低刀口破裂或剥落的风险。
- 降低模具成本。
- 降低成品的单件成本并改善工件的制造质量。

Advantages for the tool-user

- long tool life
- decreased likelihood of fracture or spalling of cutting edges
- reduction in tooling costs
- reduction of price-per-part and improvement in the quality of the parts being manufactured

BÖHLER K390 MICROCLEAN®

热处理说明

退火

- 完全退火后硬度最高：280 HB

应力消除

- 650–70℃（1200–1290 °F)。
- 熟透后于中性气体中保温1–2小时。
- 炉内缓慢冷却。

淬火

- 1030–1080℃/油冷，氮气冷却。
- 钢材于淬火温度热透后：
  1030–1150℃保温20–30分。
  1180℃保温10分。
- 要求韧性高时，用低温淬火。
- 要求高耐磨损性时，用高温淬火。

回火

- 淬火后立即缓慢加热到回火温度。
- 炉内保温时间：工件厚度
  每20mm保温1小时，最少2小时。
- 空冷。
- 建议最少回火3次。
- 可达硬度：58–64HRC。

Instructions for heat treatment

Annealing

- Hardness after annealing: max. 280 HB

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.

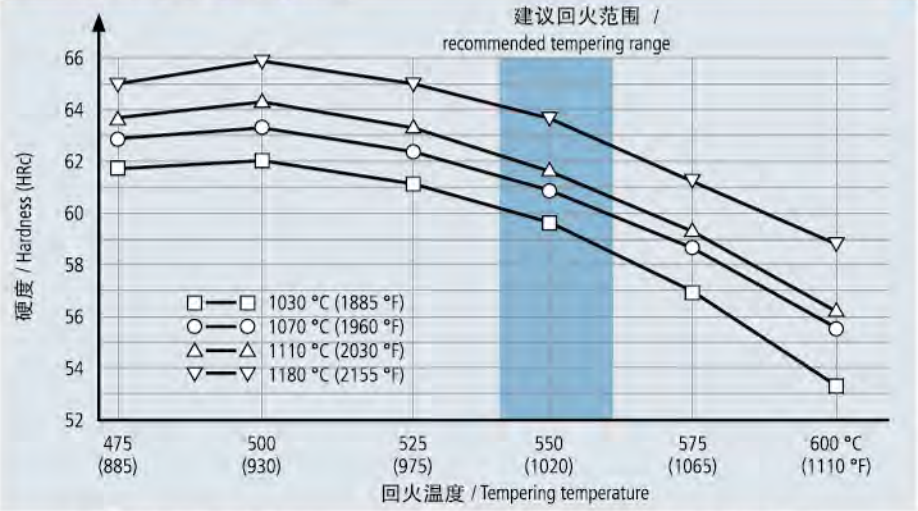
Hardening

- 1030 to 1180 °C (1885 – 2155 °F)/oil, N_2
- Following temperature equalisation:
  20 – 30 minutes for a hardening temperature of 1030 – 1150°C (1885 – 2100 °F)
  10 minutes for a hardening temperature of 1180 °C (2155 °F)
- Where higher toughness is required use a lower hardening temperature
- Where higher wear resistance is required use a higher hardening temperature

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

回火曲线图 / Tempering chart



真空淬火炉：氮气冷却5bar

hardened in vacuum furnace: N_2 cooling, 5 bar

连续冷却CCT曲线
/ Continuous cooling CCT curves

奥氏体化温度：1180℃

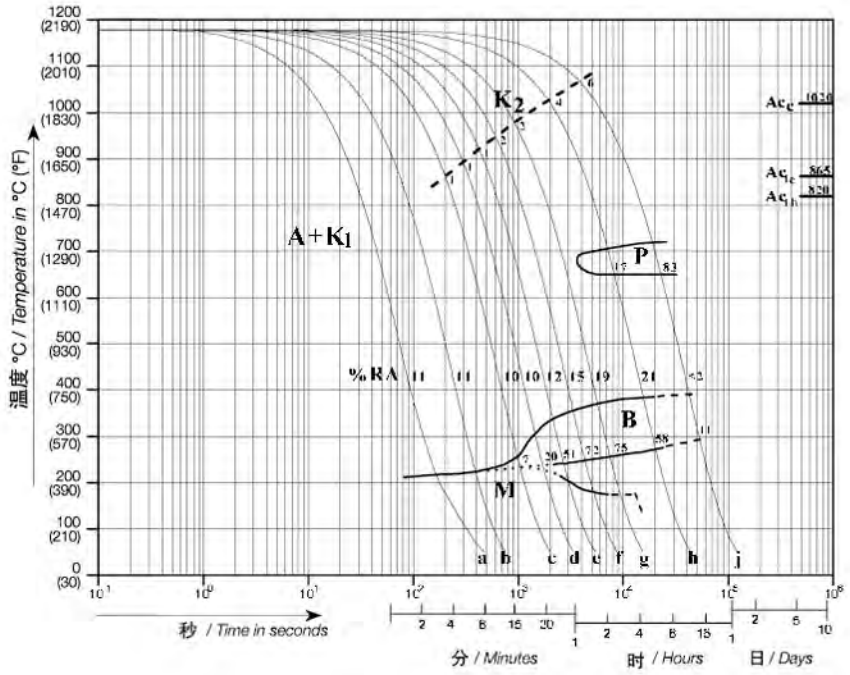
保温：5分钟

0,4 … 180 冷却参数从800–500℃所需时间
单位：秒x10^{-2}

Austenitizing temperature: 1180 °C (2155 °F)
Holding time: 5 minutes

0,4 … 180 cooling parameter, i.e. duration of cooling from 800 – 500° C (1470 – 930 °F) in s x 10^{-2}

试样 / Sample	λ	HV_{10}
a	0,4	931
b	1,1	919
c	3,0	866
d	5,0	870
e	8,0	819
f	13,0	728
g	23,0	635
h	65,0	564
j	180,0	371



定量相图 /
Quantitative phase diagram

K1 奥氏体化未溶解的共晶碳化物 (10%) /
carbides which are not dissolved during austenitization 10%)

K2 由奥氏体化淬火时间始析出2次碳化物 /
start of carbide precipitation during quenching from austenitizing temperature

LK 莱氏体 / Ledeburitic carbides

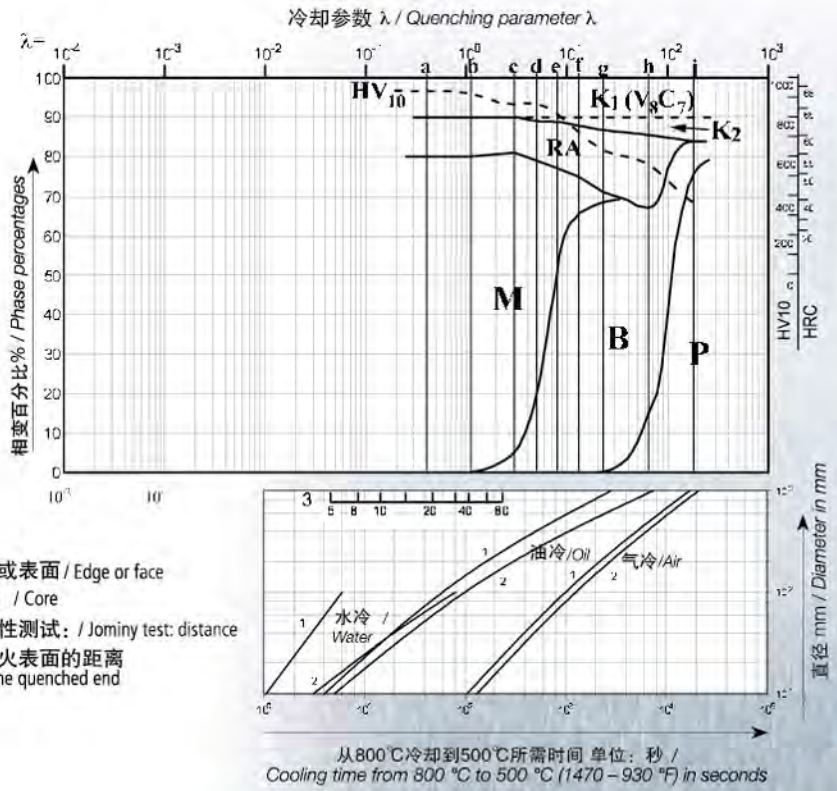
RA 残留奥氏体 / Retained austenite

A 奥氏体 / Austenite

M 马氏体 / Martensite

P 珠光体 / Perlite

B 贝氏体 / Bainite



1 边缘或表面 / Edge or face
2 心部 / Core
3 淬透性测试：/ Jominy test: distance 至淬火表面的距离 from the quenched end

BÖHLER K390 MICROCLEAN®

状态：退火态，图表仅供参考

用硬质合金车削				
车削深度 mm	0,5 – 1	1 – 4	4 – 8	über 8
进给 mm/u.	0,1 – 0,3	0,2 – 0,4	0,3 – 0,6	0,5 – 1,5
BOEHLERIT-牌号	SB10, SB20	SB10, SB20, EB10	SB30, EB20	SB30, SB40
ISO-牌号	P10, P20	P10, P20, M10	P30, M20	P30, P40
		切削速度 v_c (m/min)		
可换式刀具 寿命 15min	210 – 150	160 – 110	110 – 80	70 – 45
钎焊硬质合金刀具 寿命 30min	150 – 110	135 – 85	90 – 60	70 – 35
镀层可换式刀具 BOEHLERIT LC 225 C BOEHLERIT LC 235 C	 bis 230 bis 160	 bis 200 bis 150	 bis 150 bis 100	 bis 100 bis 60
钎焊硬质合金的切削角度 前角 后角 倾角	 6° – 12° 6° – 8° 0°	 6° – 12° 6° – 8° -4°	 6° – 12° 6° – 8° -4°	 6° – 12° 6° – 8° -4°

用高速钢车削				
车削深度 mm	0,5	3	6	
进给 mm/rev.	0,1	0,4	0,8	
BÖHLER-/DIN-牌号		S700 / DIN S10-4-3-10		
		切削速度 v_c (m/min)		
寿命 60min	30 – 20	20 – 15	18 – 10	
前角 后角 倾角	14° 8° -4°	14° 8° -4°	14° 8° -4°	

以镶齿铣刀铣削				
进给 mm/rev.	bis 0,2			
		切削速度 v_c (m/min)		
BOEHLERIT LW 225	150 – 90			
BOEHLERIT SB40/ISO P40	70 – 45			
BOEHLERIT LC 444 W	80 – 60			

以镶齿硬质合金钻孔				
钻头直径	3 – 8	8 – 20	20 – 40	
进给 mm/rev.	0,02 – 0,05	0,05 – 0,12	0,12 – 0,18	
BOEHLERIT/ISO-牌号		HB10 / K10		
		切削速度 v_c (m/min)		
	50 – 35	50 – 35	50 – 35	
顶角	115° – 120°	115° – 120°	115° – 120°	
后角	5°	5°	5°	

研磨

* 可能的话使用氮化硼砂轮研磨

** 研磨砂轮使用烧结刚玉

研磨方式	退火材料	已热处理材料
侧面	A 46 HV	B151 R50 B3* / A 46 GV**
平面	A 36 GV	A 46 GV
无心	A 60 KV	B151 R50 B3* / A 60 JV**
内孔	A 60 JV	B151 R75 B3* / A 60 IV
搪孔	A 100 IV	B126 R100 B6* / A 100 JV**

BEARBEITUNGSHINWEISE
MACHINING RECOMMENDATIONS

Condition: annealed. Figures given are guidelines only.

Turning with sintered carbide				
Depth of cut mm (inches)	0.5 – 1 (.02 – .04)	1 – 4 (.04 – .16)	4 – 8 (.16 – .31)	over 8 (over .31)
Feed mm / rev. (inches/rev.)	0.1 – 0.3 (.004 – .012)	0.2 – 0.4 (.008 – .016)	0.3 – 0.6 (.012 – .024)	0.5 – 1.5 (.020 – .060)
BOEHLERIT grade	SB10, SB20	SB10, SB20, EB10	SB30, EB20	SB30, SB40
ISO grade	P10, P20	P10, P20, M10	P30, M20	P30, P40
		Cutting speed v_c m/min (f.p.m)		
Indexable inserts Tool life: 15 min.	210 – 150 (690 – 490)	160 – 110 (525 – 360)	110 – 80 (360 – 260)	70 – 45 (230 – 150)
Brazed carbide tools Tool life: 30 min.	150 – 110 (490 – 360)	135 – 85 (445 – 280)	90 – 60 (295 – 195)	70 – 35 (230 – 115)
Coated indexable inserts BOEHLERIT LC 225 C BOEHLERIT LC 235 C	 up to 230 (755) up to 160 (525)	 up to 200 (655) up to 150 (490)	 up to 150 (490) up to 100 (330)	 up to 100 (330) up to 60 (195)
Tool angles for brazed carbide tools Rake angle Clearance angle Inclination angle	 6° – 12° 6° – 8° 0°	 6° – 12° 6° – 8° -4°	 6° – 12° 6° – 8° -4°	 6° – 12° 6° – 8° -4°

Turning with high speed steel				
Depth of cut mm (inches)	0.5 (.02)	3 (.12)	6 (.24)	
Feed mm / rev. (inches/rev.)	0.1 (.004)	0.4 (.016)	0.8 (.032)	
HSS-grade BÖHLER/DIN		S700 / DIN S10-4-3-10		
		Cutting speed v_c m/min (f.p.m)		
Tool life: 60 min.	30 – 20 (100 – 65)	20 – 15 (65 – 50)	18 – 10 (60 – 35)	
Rake angle	14°	14°	14°	
Clearance angle	8°	8°	8°	
Inclination angle	-4°	-4°	-4°	

Milling with inserted tooth cutter				
Feed mm/tooth (inches/tooth)	up to 0.2 (.008)			
		Cutting speed v_c m/min (f.p.m)		
BOEHLERIT LW 225	150 – 90 (490 – 295)			
BOEHLERIT SB40/ISO P40	70 – 45 (230 – 150)			
BOEHLERIT LC 444 W	80 – 60 (260 – 195)			

Drilling with inserted carbide				
Drill diameter mm (inches)	3 – 8 (.12 – .31)	8 – 20 (.31 – .80)	20 – 40 (.80 – 1.6)	
Feed mm / rev. (inches/rev.)	0.02 – 0.05 (.001 – .002)	0.05 – 0.12 (.002 – .005)	0.12 – 0.18 (.005 – .007)	
BOEHLERIT/ISO grade		HB10 / K10		
		Cutting speed v_c m/min (f.p.m)		
	50 – 35 (165 – 115)	50 – 35 (165 – 115)	50 – 35 (165 – 115)	
Point angle	115° – 120°	115° – 120°	115° – 120°	
Clearance angle	5°	5°	5°	

Grinding

* For these applications, CBN discs should be used if possible

** For these applications, grinding discs with sintered corundum should be used

Grinding process	soft annealed	hardened
Circumference grinding	A 46 HV	B151 R50 B3* / A 46 GV**
Face grinding	A 36 GV	A 46 GV
Cylindrical surface grinding	A 60 KV	B151 R50 B3* / A 60 JV**
Internal circular grinding	A 60 JV	B151 R75 B3* / A 60 IV
Deep form grinding	A 100 IV	B126 R100 B6* / A 100 JV**

使用无氯漂白纸张 无环境污染 / Printed on chlorine-free bleached paper having no pollution effects.

您的伙伴:

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