



HIGH PERFORMANCE MOLD STEELS FOR INJECTION OF REINFORCED PLASTICS

用於射出強化塑膠的高性能模具鋼

用於射出強化塑膠的 高性能模具鋼

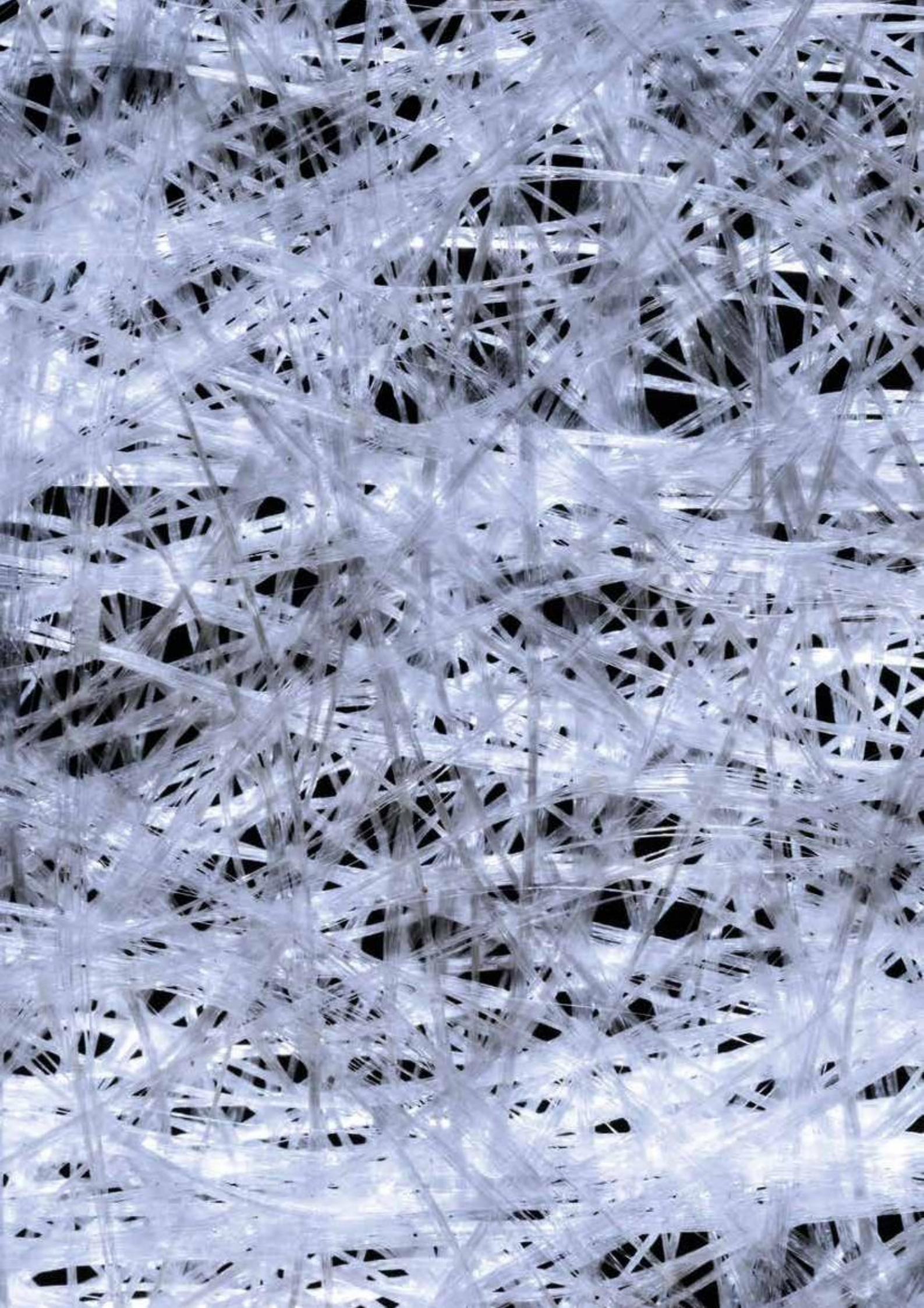
最新的工業製程，特別是汽車及電子產業有用強化塑膠取代金屬的趨勢。這種塑膠零件重量更輕，有助於減少二氧化碳排放，符合目前全球各地對於環境保護的潮流。另外複雜的幾何形狀，薄壁厚度和大面積的零件使得塑膠材料中必須增加玻璃纖維或碳纖維以獲得足夠的穩定性。

由纖維強化的塑膠往往比傳統塑膠有更大的磨蝕性，因此可能導致注塑模具的過早磨損。為了減少模具過早磨損，奧鋼聯百樂鋼提供各種高質量的工具鋼，為強化塑膠製程的耐用度樹立了新的標準。

HIGH PERFORMANCE MOLD STEELS FOR INJECTION OF REINFORCED PLASTICS

Modern industrial parts production in mainly automotive and electronic industries is characterized by the trend to substitute metals by reinforced plastics. Being much lighter and therefore weight-saving, such plastic components help to reduce CO2 emissions, which is a clear ecologic focus worldwide. Intricate geometries, thin wall-thicknesses and large areas of the parts are characteristics that call for a growing amount of glass or carbon fibers in the plastics to obtain sufficient stability.

Plastics reinforced by fibers tend to be much more abrasive than conventional plastics and thus may cause premature wear of an injection mold. In order to counteract excessive and early wear in molds, voestalpine Böhler Edelstahl is offering a wide variety of high-quality tooling steels that are setting new standards in the production of heavy-duty components made from reinforced plastics.



TRENDS AND REQUIREMENTS

趨勢與市場需求

- » New types of high performance plastics (GF, CF, fibre length, filler material)
- » Increasing wear resistance requirements on mold material
- » Increasing corrosion resistance of mold material
- » Complexity of parts increased (light weight construction)
- » Increase productivity through shorter cycle times (thermal conductivity)
- » Higher closing pressures and processing temperatures

- » 新型強化塑膠材質 (GF, CF, 纖維長度, 纖維材質)
- » 模具鋼需增加抗磨耗性
- » 模具鋼需增加抗腐蝕性
- » 零件複雜度增加(輕結構)
- » 以縮短生產週期(cycle time)的方式增加生產效率(導熱係數)
- » 更高的閉合壓力和加工溫度

PLASTIC MOLDING 塑膠成型

EXAMPLE OF “POLYMERIC LEIGHT WEIGHT CONSTRUCTION”

以聚合物輕質結構為例:



Prototype:
Plastic steering case
樣品: 塑膠轉向軸套

- » Equal cost part made of 50% glass fiber reinforced PA (Ultrad® A3R) with metal inserts
- » Special FEM-Design modification
- » Service temperature: max. 125 °C
- » **50% weight savings**

Source: ThyssenKrupp techforum 1/2014



Steering casing
Al- HPDC part
(Symbolic picture)
鋁合金轉向軸套

- » 成本相同 · 使用50%玻璃纖維強化PA (Ultrad® A3R)和金屬嵌件製成
- » 特殊FEM 設計改良
- » 工作溫度: 最高 125 °C
- » **重量減輕50%**

資料來源: ThyssenKrupp techforum 1/2014

PLASTIC PROCESSING 塑膠加工

SELECTED PARTS/COMPONENTS MADE OF LONG FIBER REINFORCED THERMOPLASTIC

特殊零件/部件使用長纖強化熱塑成型塑膠製成



Long glass-fiber reinforced car front end

Source: M. Schemme, FH Rosenheim

長纖強化塑膠製 汽車前端支架



Long-fiber reinforced door module

Source: M. Schemme, FH Rosenheim

長纖強化塑膠製 車門模組



Short glass-fiber reinforced brake/clutch

pedal holder

Source: POLYCOM

短纖強化塑膠製 煞車/離合器踏板支架



Oilpan

Source: LANXESS

油底殼

HIGH PERFORMANCE PLASTICS 強化塑膠

Automotive

汽車產業



PA6 – GF65



PA66 – CF35

Household

家庭用品



PA66 – CF35



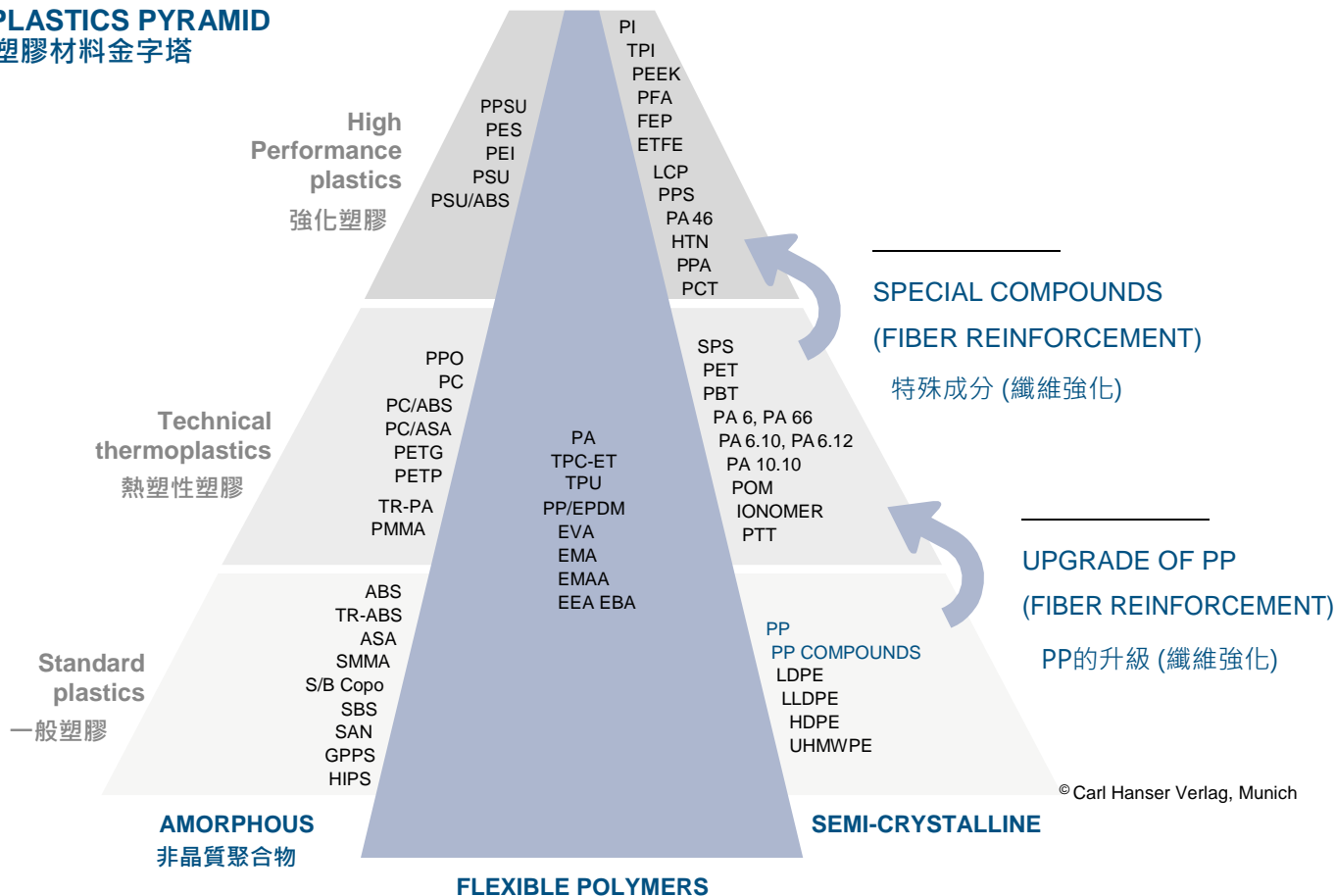
PC+ABS – GF40



PA6 – GF40

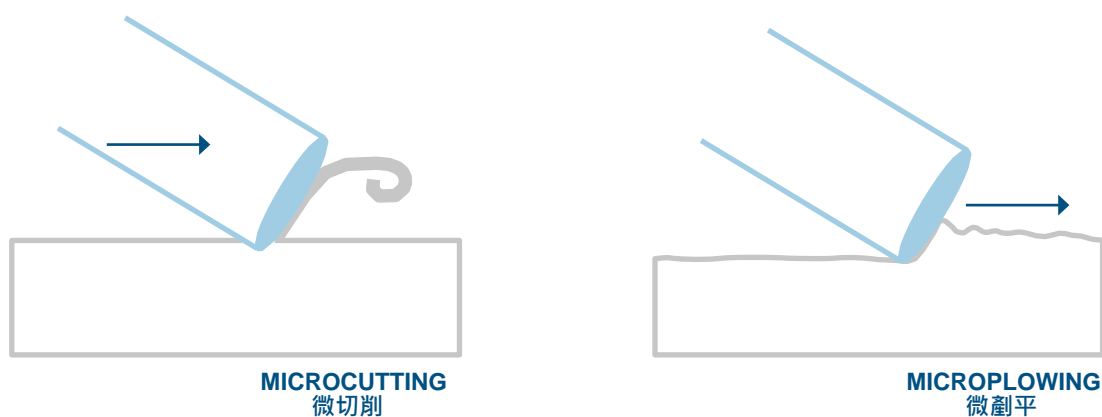


PLASTICS PYRAMID 塑膠材料金字塔



WEAR 磨耗機制 MECHANISM

Fiber motion causes abrasive wear by 玻璃纖維造成的磨料磨耗



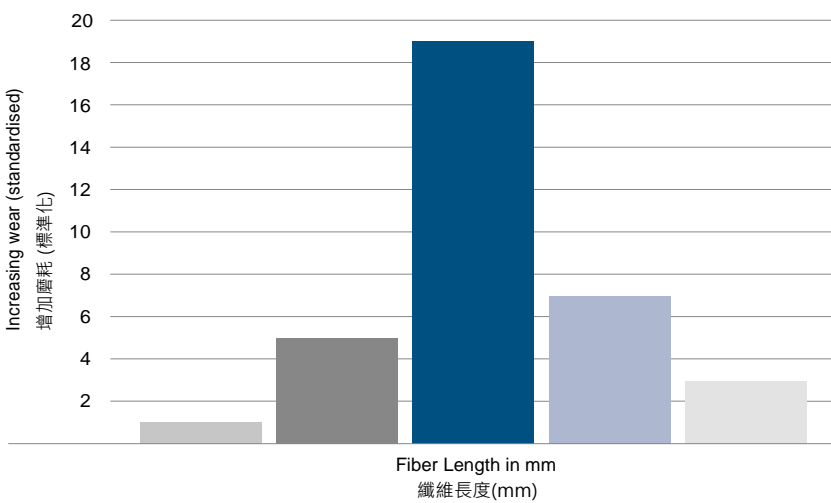
Beside glass fibers also glass balls, metal oxides (titanium oxide, chromium oxide), calcium carbonates, silica components (sand, quartz), ceramics are forcing abrasive wear.

除玻璃纖維外，還有玻璃球、金屬氧化物（氧化鈦、氧化鉻）、碳酸鈣、二氧化矽成分（沙子、石英）、陶瓷.....等會造成磨料磨耗

Source: Department of Injection Moulding of Polymers, University of Leoben

INFLUENCING 影響因素 FACTORS

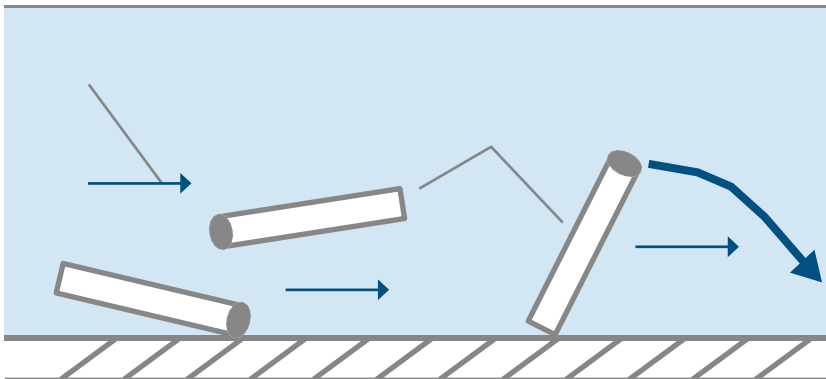
Fiber Length 纖維長度



- Typical fiber diameter: 10 µm 常見纖維直徑: 10µm
- Length up to 200 µm 長度小於200µm
 - 200 µm < L < 500 µm 長度介於200µm至500µm之間
 - 500 µm < L < 1000 µm 長度介於500µm至1000µm之間
 - 1000 µm < L < 2000 µm 長度介於1000µm至2000µm之間
 - Length > 2000 µm 長度大於2000µm

Source:
Department of Injection
Moulding of Polymers,
University of Leoben

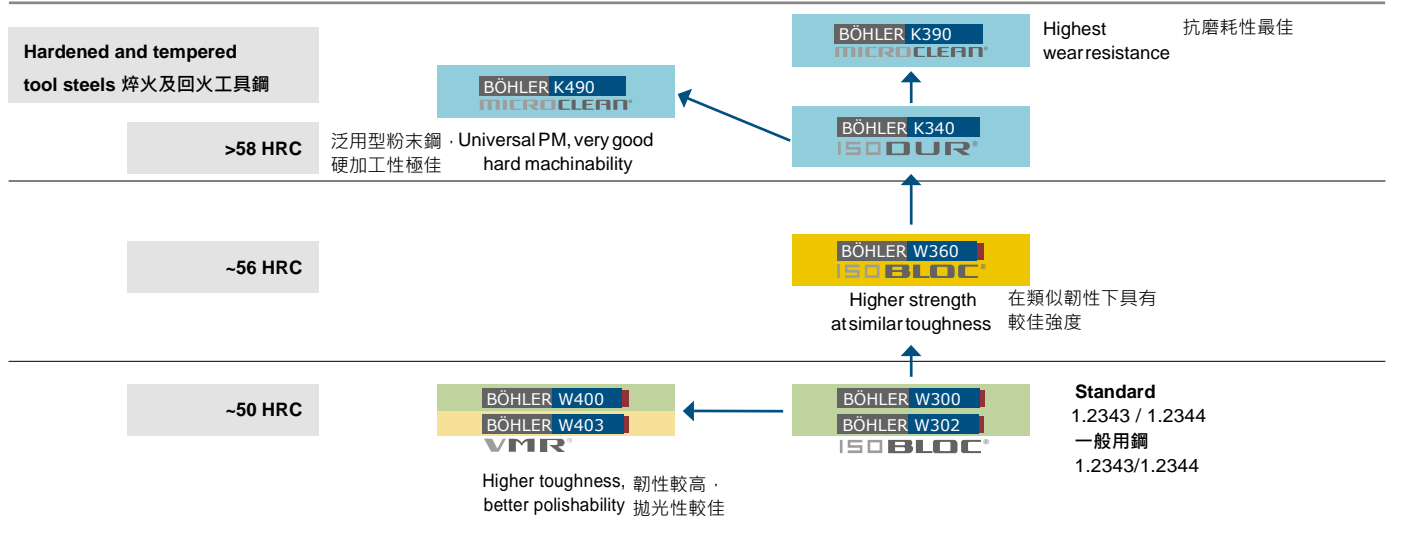
Polymer melt with glass fibers 含玻璃纖維之聚合物溶體



PRODUCT SELECTION – HIGH PERFORMANCE MOLD STEELS 高性能模具鋼-鋼種選擇

非抗腐蝕性鋼種

Non corrosion resistant steels



- up to ~20% GF
- up to ~30% GF
- up to ~60% GF
- up to ~65% GF

Examples for processed plastics 適用塑膠材料舉例

PA6 - GF50
PA66 - GF40
PA66 - GF35
PA66 - GF30
PC+ABS-GF40
POM - CF35
PA6 - GF65
PA6 - CF45

MICROCLEAN[®]
粉末冶金鋼種

Powder metallurgical steels

VMR[®]
Special materials subjected to vacuum refining or 真空精鍊或重熔 melting during at least one stage of manufacture.

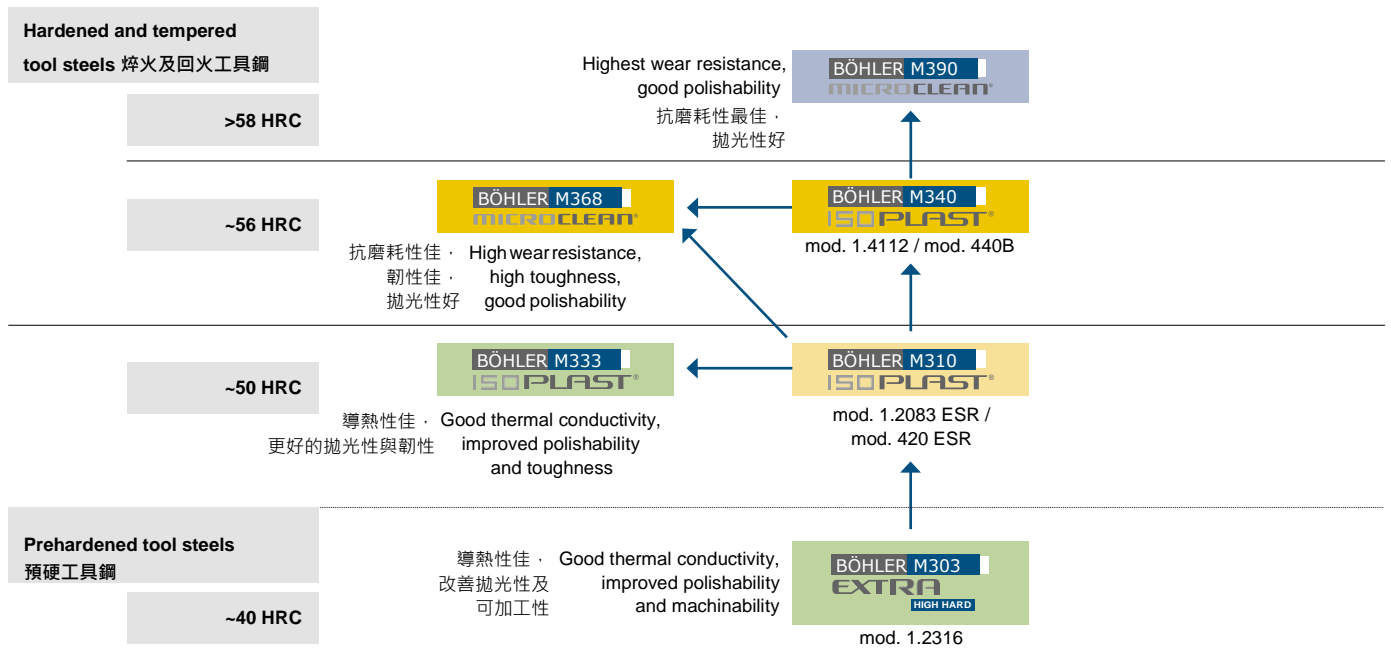
ISODUR[®]
Cold work tool steels in ESR quality 電渣重溶精鍊之冷作鋼

ISOBLOC[®]
Hot work tool steels in ESR quality with special 電渣重溶精鍊 · 並經過特殊熱處理之熱作鋼

BÖHLER grade 百樂鋼鋼種	Chemical composition in weight % 合金成分 (重量百分比)						Standard 通用鋼號	Carbide vol-[%] hardened 碳化物比例 (%)	Wear resistance 抗磨耗性
	C	Cr	Mo	V	W	Others			
BÖHLER W300 ISOBLOC	0.4	5.0	1.3	0.4	-	-	1.2343 / H11	< 1	★
BÖHLER W302 ISOBLOC	0.4	5.2	1.4	1.0	-	-	1.2344 / H13	< 1	★
BÖHLER W400 VMR	0.4	5.0	1.3	0.5	-	-	1.2340 / ~H11	< 1	★
BÖHLER W403 VMR	0.4	5.0	2.8	0.7	-	-	1.2367	< 1	★
BÖHLER W360 ISOBLOC	0.5	4.5	3.0	0.6	-	-	-	< 1	★★★
BÖHLER K340 ISODUR	1.1	8.3	2.1	0.5	-	+Al, Nb	-	8.5	★★★★
BÖHLER K490 MICROCLEAN	1.4	6.4	1.5	3.7	3.5	+Nb	-	10	★★★★★
BÖHLER K390 MICROCLEAN	2.5	4.2	3.8	9.0	1.0	+ 2.0 Co	-	17	★★★★★★

抗腐蝕性鋼種 (基地中最小游離鉻含量為13%)

Corrosion resistant steels (minimum free chromium content in the matrix of 13%)



- up to ~10% GF
- up to ~15% GF
- up to ~60% GF
- up to ~65% GF

Examples for processed plastics
PVC, CPVC, PES, PSU, PVDF, ABS
適用塑膠材料舉例
PVC, CPVC, PES, PSU, PVDF, ABS

MICROCLEAN®

Powder metallurgical steels 粉末冶金鋼種

ISOPLAST®

Plastic mould steels in ESR quality 電渣重溶精煉之塑膠模具鋼

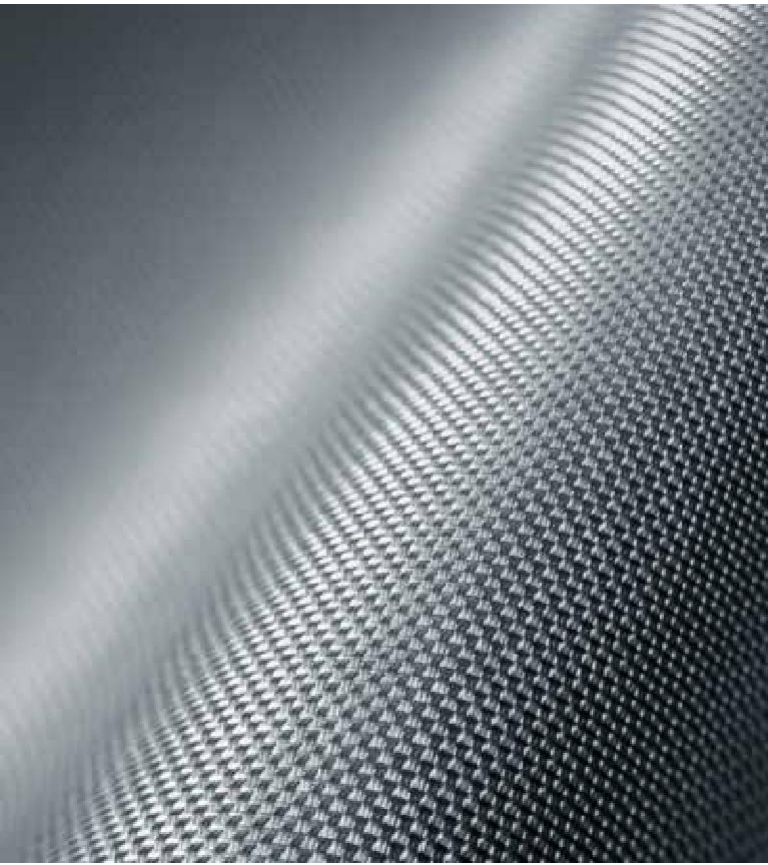
EXTRA

Special property and/or achievement characteristics
擁有特殊性能之鋼種

BÖHLER grade 百樂鋼鋼種	Chemical composition in weight % 合金成分 (重量百分比)						Standard 通用鋼號	Carbide vol-[%] hardened 碳化物比例 (%)	Wear resistance 抗磨耗性
	C	Cr	Mo	Ni	V	Others			
BÖHLER M303 EXTRA HIGH HARD	0.27	14.50	1.00	0.85	-	+N	~1.2316	< 1	★
BÖHLER M333 ISOPLAST®	0.24	13.25	+	+	+	+N	~1.2083 / ~420	< 1	★★
BÖHLER M310 ISOPLAST®	0.38	14.30	-	-	0.20	-	~1.2083 / ~420	1.5	★★
BÖHLER M340 ISOPLAST®	0.54	17.30	1.10	-	0.10	+N	-	ca. 8%	★★★
BÖHLER M368 MICROCLEAN®	0.54	17.30	1.10	-	0.10	+N	-	ca. 8%	★★★
BÖHLER M390 MICROCLEAN®	1.90	20.00	1.00	-	4.00	W=0.60	-	ca. 20%	★★★★★

HEAT TREATABLE, WEAR RESISTANT MOLD STEEL

可熱處理之抗磨耗模具鋼



The wear is determined either by mass loss or volumetrically by 3D measurement of the sample surfaces before the test and after injection of, for example, 25 kg or 50 kg of glass fiber reinforced plastic molding compound.

The wear apparatus for testing the abrasive/corrosive wear on the tribosystem polymer melt/steel is installed in the injection molding machine in the form of an injection molding tool. The wear samples, which have the same temperature as the melt, form a rectangular gap in which large local shear stresses and shear rates can be generated. The melt is injected through the wear gap and generates the material removal on the surfaces of the two wear samples (each 15 x 12 x 5 mm). The entire dosing volume of the plasticized molding compound is injected at a defined injection pressure, defined injection rate and a specified melt temperature.

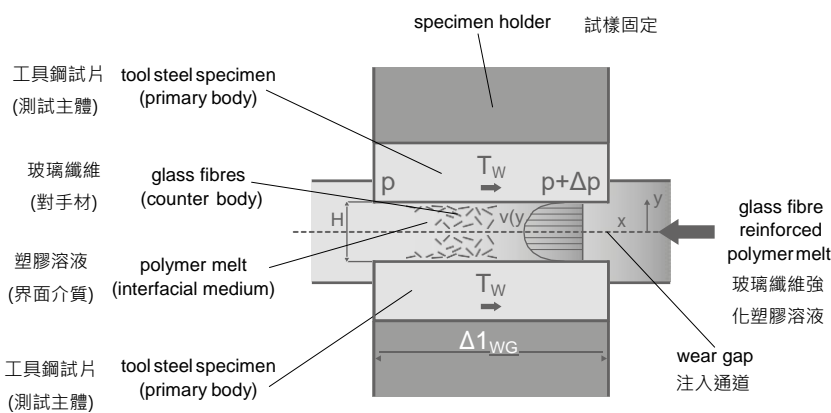
The wear is determined by the material removal (mg/cm^2) or the material removal height (μm) before and after injected a defined amount of plastic melt.

磨耗的測量為樣本注入約25至50公斤之玻璃纖維強化塑膠之前與之後的質量損失或3D測量之表面體積損失。

測試磨料磨耗及腐蝕磨耗的儀器與其他零件同樣安裝在射出機內。被測試的兩塊鋼種樣本，分別被放置在射出路徑的上下兩側，並加熱到與塑膠溶液相同溫度，便會形成一個高剪應力、高剪切率的通道。當塑膠溶液被注入該通道時，玻璃纖維便會磨蝕兩塊樣本(5 x 12 x 15 mm)的表面。整體塑膠溶液注入的壓力、速率及溫度均為控制變數，維持不變。

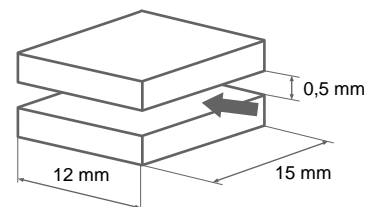
磨耗測試的結果為樣本表面被移除的重量(mg/cm^2)，或磨痕的深度(μm)決定。

Small Plates Wear Tests 小樣本磨耗測試



Mean depth of abrasion or weight loss of the testing plates indicates the wear resistance.

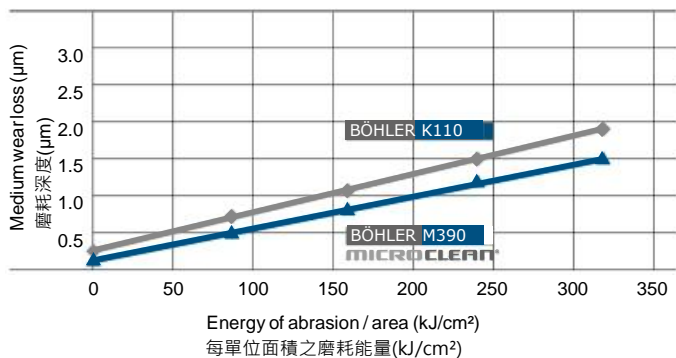
測試樣本的平均磨損深度或重量損失就能測試出耐磨性



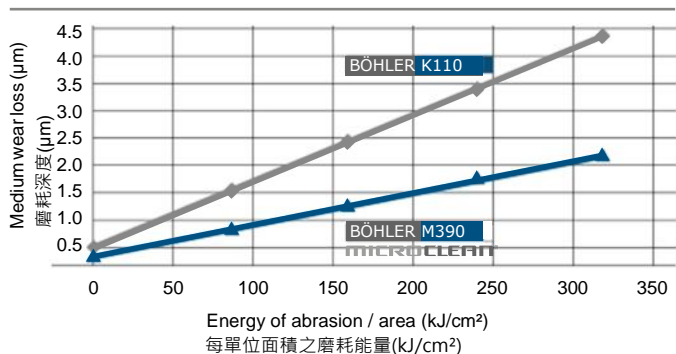
腐蝕磨耗和磨料磨耗的影響 - 實驗室測試結果
K110 與 M390樣本測試之比較

EFFECT OF CORROSION AND ABRASION – LABORATORY TEST RESULTS
K110 VS. M390 MICROCLEAR, RESULTS FROM PLATES WEAR TESTS

PA 66 + 30% GF/ 300°C PA 66 + 30% 玻纖/ 300°C



PES + 30% GF/ 400°C PES + 30% 玻纖/ 400°C



Facts

- » Filling materials and additional fibers in various plastic materials have an abrasive effect
在塑膠材料中添加填充材質或纖維將產生磨耗
- » Together with corrosive media (fission products,...) tribochemical wear system emerges
當塑膠材料本身具有腐蝕性時· 模具需抵抗多重磨耗因素

%	C	Cr	Mo	V	W
K110	1.55	11.80	0.80	0.95	
M390PM	1.90	20.00	1.00	4.00	0.60

	硬度(HRC) Hardness (HRC)
K110*	58
M390PM	61

Beside wear and corrosion resistance further important factors to choose the right material are:

- » Tool design (complex/simple, deep/shallow cavity, ...)
- » Tool size
- » Surface requirements on the mold

Additional aspects are for instance dimensional stability, edge stability, machinability, ability for coating....

Detailed recommendations have to be checked case by case.

在選擇模具材料時· 除了考慮抵抗磨耗與腐蝕的特性外· 還有幾個重要的衡量指標

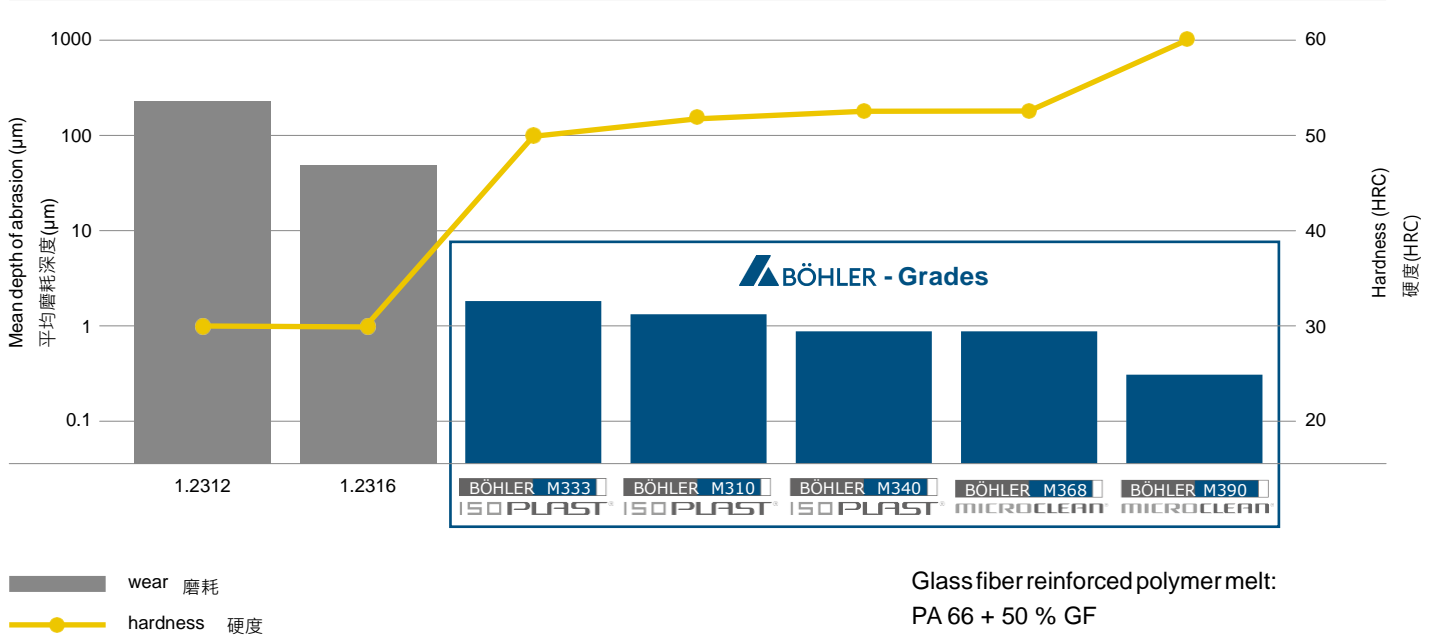
- » 模具設計 (複雜度、孔穴深淺)
- » 模具尺寸
- » 模具表面要求

其餘要思考的還有: 尺寸穩定性· 邊角穩定性· 可加工性· 是否可以塗層...等

詳細對材質的建議需要進行個案評估後提出

WEAR RESISTANCE WITH PLATE-WEAR TEST

抗磨耗性
試片磨耗測試之結果

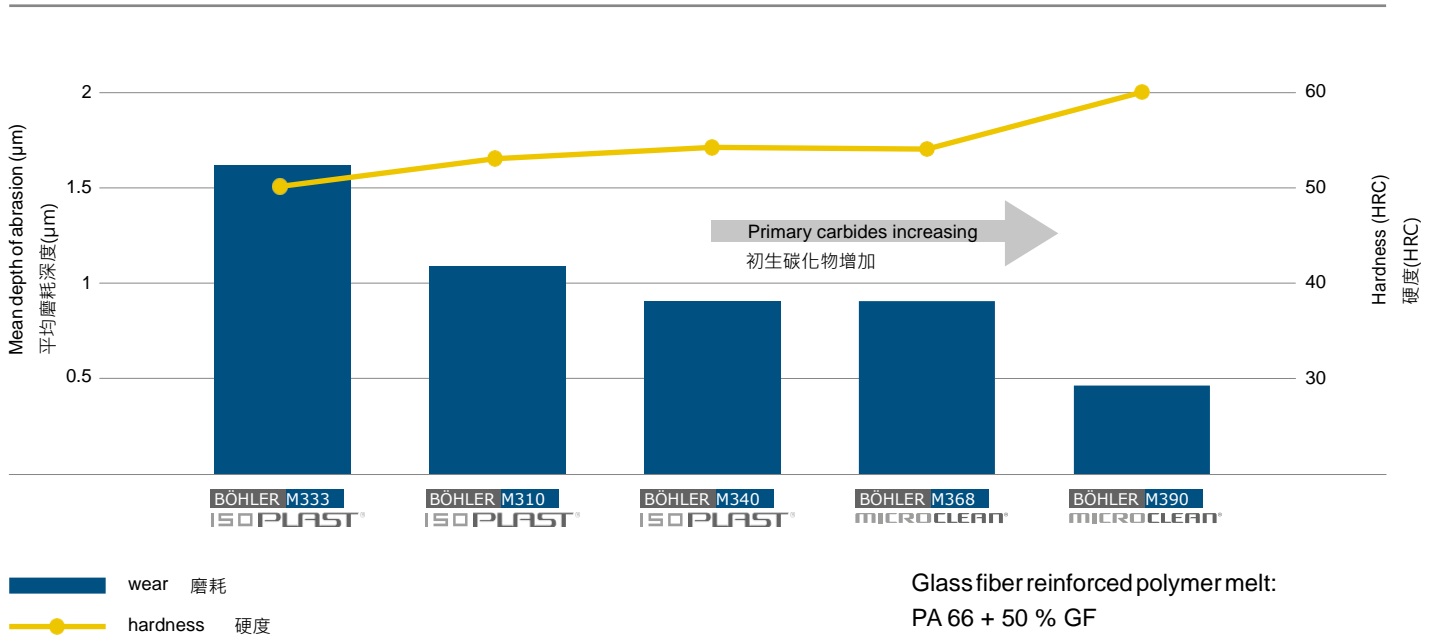


Glass fiber reinforced polymer melt:
PA 66 + 50 % GF

玻璃纖維強化塑膠
PA 66 + 50 % 玻纖

WEAR RESISTANCE WITH PLATE-WEAR TEST – DETAIL

抗磨耗性
試片磨耗測試之詳細結果



Glass fiber reinforced polymer melt:
PA 66 + 50 % GF

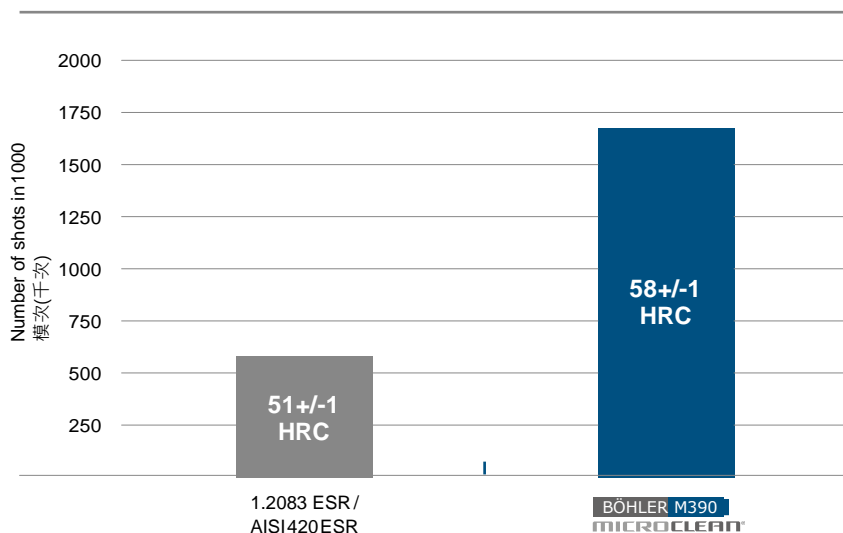
玻璃纖維強化塑膠
PA 66 + 50 % 玻纖

CASE STUDIES 實際案例

用於繼電器的電氣元件基板

ELECTRICAL COMPONENTS BASE PLATES FOR RELAYS

BÖHLER M390
MICROCLEAN®



Processed material:

PBT Vestodur X7212 NF + 45% GF

Cause for tool damage: Wear

射出塑膠材質:

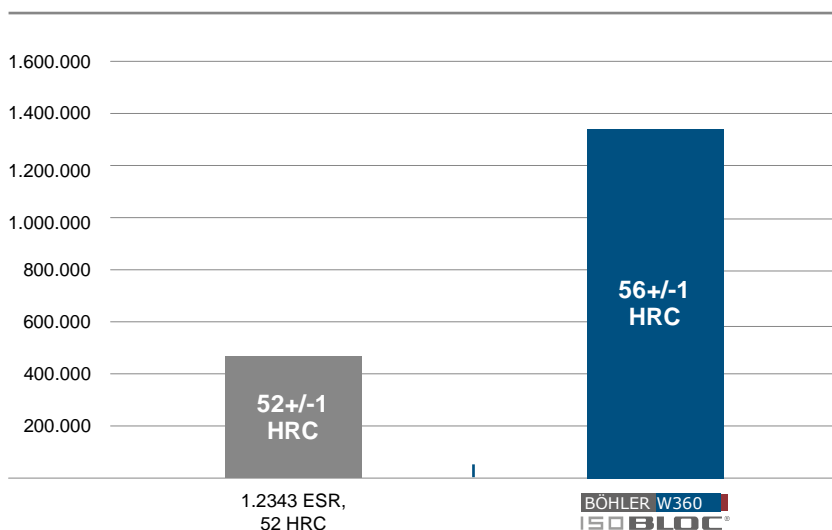
PBT Vestodur X7212 NF + 45% 玻纖

模具失效原因: 磨耗

家庭用品齒輪

HOUSEHOLD COMPONENTS GEARS

BÖHLER W360
ISOBLOC®



Processed material: PA66 + GF35

Cause for tool damage: Wear

射出塑膠材質: PA66 + 玻纖35

模具失效原因: 磨耗



QUALITY LEVELS TECHNOLOGIES

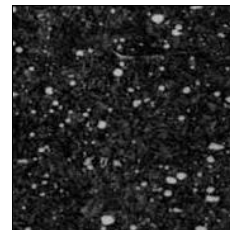
品質層面
技術資訊

Conventional Production

傳統式鍊鋼

THE “STANDARD” MATERIAL FOR ORDINARY STRESS, NORMAL LEVEL WITH: “一般”材質擁有一般水準的機械特性

Structural conditions	結構條件
Carbide distribution	碳化物分布
Homogeneity	均質化
Individual carbides	獨立碳化物
Degree of purity	清淨度
Toughness	韌性



Microstructure
BÖHLER K110
金相
BÖHLER K110

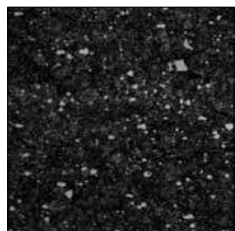


Electro Slag Remelting 電渣重溶式鍊鋼 Production

ISOPLAST® ISO DUR® ISO BLOC®

IMPROVED SERVICE LIFE DUE TO: 擁有以下特性得改善模具壽命

Least possible inclusion content	不純物的可能含量極低
Lower micro and macro segregation	較少的偏析
Good homogeneity and a higher degree of purity	均質化、清淨度佳
Homogenic structure throughout the entire cross-section and bar length	均勻結構含括整個橫截面與長度
Producing larger bar dimensions at a constant carbide distribution	生產碳化物均勻分布的大尺寸鋼材
Uniform dimensional stability	尺寸穩定性
Broad range of application owing to a high degree of toughness	韌性高，因此應用範圍廣泛



Microstructure
BÖHLER K340
in ESR quality

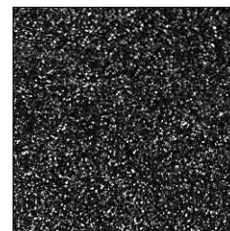
金相
BÖHLER K340
ESR電渣重溶鋼種

Powder Metallurgical Production

MICROCLEAN®

FOR THE HIGHEST DEMANDS: 針對最高規格要求

Segregation free high performance steel	無偏析高性能鋼
Finest carbide distribution	碳化物分佈最微細
Highest metallurgical purity	最佳清淨度
Isotropic properties	等向性
Maximum wear resistance with a simultaneously higher toughness	最大的耐磨性，同時具有更高的韌性
High degree of hardness	高硬度
Very good dimensional stability	尺寸穩定性佳
High compressive strength	高抗壓強度



Microstructure
BÖHLER K390
MICRO-CLEAN

金相
BÖHLER K390
MICRO-CLEAN
粉末冶金鋼種

梧濟工業股份有限公司

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