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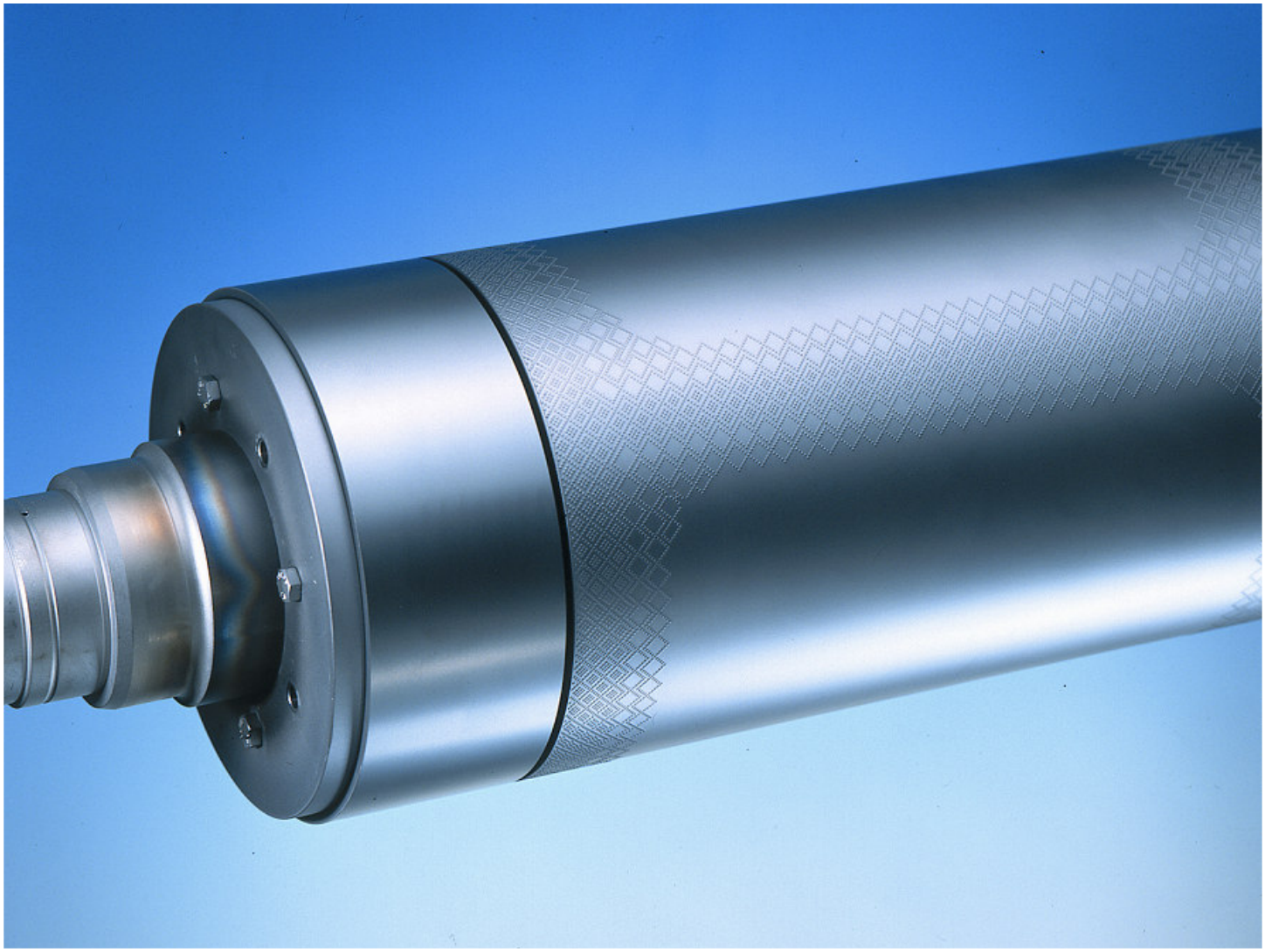
MAXIT® PVD Coatings-
Solutions for the Mould and Die Industries

MAXIT® 涂层----模具行业解决方案



Wear Mechanisms
磨损形式

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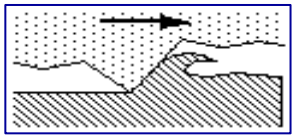
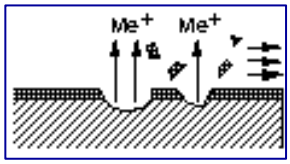
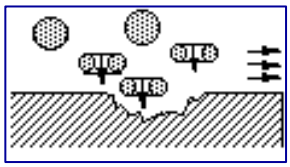


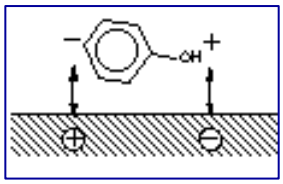
Abrasive Wear occurs as a result of micro-cutting by hard particles encapsulated within the processing material. The geometry and hardness of these particles influence the wear mechanism. **磨粒磨损**



In some processes, **corrosive ions** form during processing. This can result in component surface and geometric degradation. **腐蚀分解**



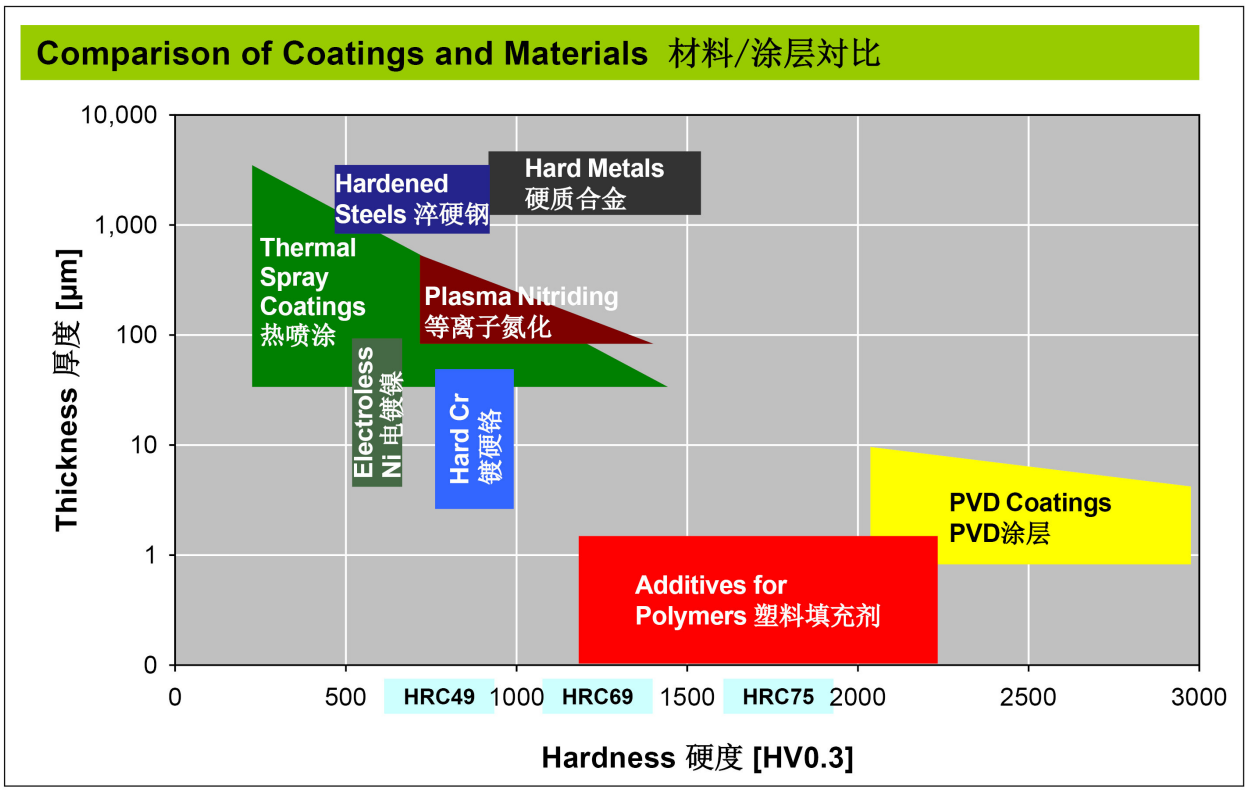
Cavitation is the result of rapid, localized pressure drops in liquid media. Bubbles created by cavitating conditions rapidly collapse, creating a shock wave near the wall of the tool surface that causes surface damage. **汽蚀**



Adhesive Wear (Films) are based on cold welding, electrostatic forces, chemical bonding, wetting and micro-welding, which lead to abrasive wear by tribological oxidation.**粘着磨损**

Erosive Wear is caused by the impingement of abrasive particles on a surface. Passivated layers can be destroyed by erosive media, thus accelerating corrosive processes. **冲蚀磨损**

Comparison of Coatings and Materials 材料/涂层对比



Get to Know MAXIT® Coatings
认识 MAXIT® 涂层

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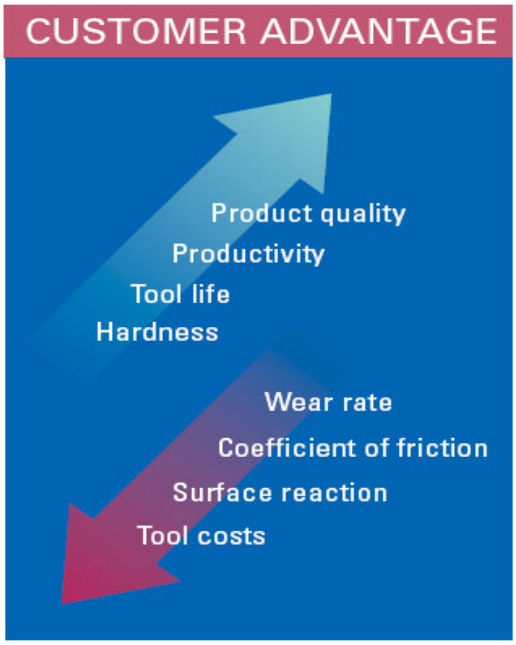


MAXIT® coatings help mould customers maximize their profits.
MAXIT® 涂层帮助模具客户实现最佳收益

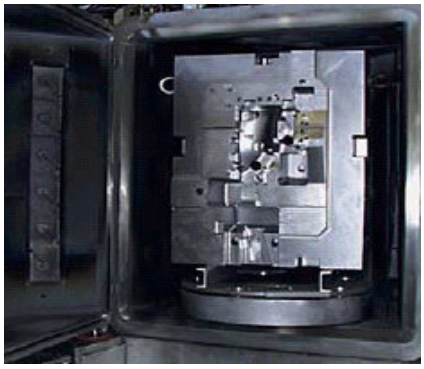
Fast turn-round time, reduced use of consumables and low maintenance are all important requirements for any mould & die user.
快速运转，低消耗，低维护是任何模具用户重要的追求。

Thin film technology has firmly established itself as an effective method for reducing **abrasive wear**, **adhesion**, **galling**, **friction**, **chemical attack** and **thermal attack**. These coatings help to reduce tooling costs, increase productivity and product surface quality.
薄膜技术已被确立为减少磨损，表面粘结，磨伤，摩擦，化学侵蚀和热侵蚀的有效方法。这些涂层可以帮助降低模具成本，提高生产力和产品表面品质。

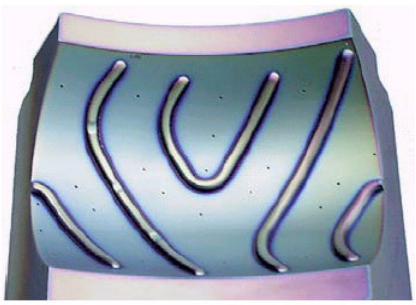
Sulzer Metco has several decades of experience serving the Mould & Die industry. Its combined application of plasma nitriding and PVD hard coating is a particularly efficient tool for reducing abrasion and cold bonding when forming metals, as well as corrosion and adhesion when processing plastics or elastomeric materials.
苏尔寿美科在模具行业有数十年的经验。其特有的等离子氮化与PVD涂层组合处理工艺为解决金属成型加工中存在的磨损，冷焊问题和塑料与热塑性弹性体加工中存在的腐蚀与粘附问题提供了有效的解决方案。

Properties of Maxit® coatings　Maxit® 涂层性能

Coating material 涂层材料	TiN 氮化钛	TiCN 氮碳化钛	CrN 氮化铬	Multi-CrN 氮化铬-多层	CrN-mod 氮化铬-改进型	AlTiN 氮化铝钛	W-C:H 低润滑涂层
Microhardness HV(1N) 微硬度	2550±250	3050±250	2300±200	2300±200	2450±250	2900±200	1150±250
Layer thickness (µm) 涂层厚度	1-4	1-4	2-5	3-9	3-9	1-5	1-5
Colour 颜色	gold-yellow 金黄色	red-brown/ grey 棕红色/灰色	silver 银色	silver 银色	colorful 彩色	anthracite 无烟煤色	grey/black 灰色/黑色
Coating structure 涂层结构	Monolayer 单层	Monolayer 单层	Monolayer 单层	Multilayer 多层	Multilayer 多层	Nanostructure 纳米结构	Multilayer 多层
Max. usage temp./ °C 最高使用温度	550±50	450±50	650±50	650±50	700±50	800±50	350±50
Electr. resistance µΩ cm 电阻	60±20	8±20	640	640	640	4000-7000	--
Thermal conductivity 热传导性 $(Ws^{0.5})/m^2K$	8800±1000	8100±1400	8100±2600	8100±2600	8100±2600	7000±400	7600±1000
Coefficient of friction (dry)干摩擦系数	0.65-0.70	0.40-0.50	0.50-0.60	0.50-0.60	0.50-0.60	0.55-0.65	0.15-0.50
Ductility 展延性	++	+	+++	+++	+++	+	+++
Sticking resistance 抗粘着性	++	+	+++	+++	+++	+	+++
Abrasion resistance 抗磨损性	++	+++	++	++	++	+++	+
Corrosion protection 抗腐蚀性	+	+	+++	+++	+++	++	+



Injection mould for PA+35% GF, plasma nitrided and Multi-CrN coated.
用于注塑含35%玻纤的尼龙材料的注塑模具，经过离子氮化和 CrN 多层涂层组合处理可有效解决磨损。



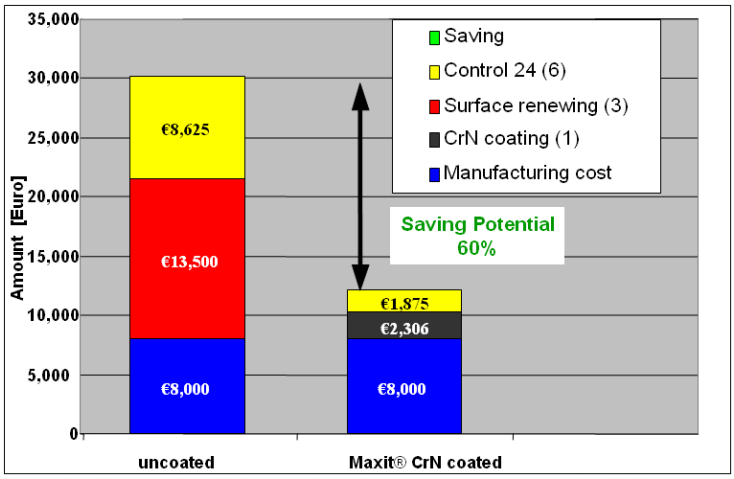
Improved separation through CrN-mod
采用CrN-mod涂层的硫化模具，生产过程中其脱模性能获得显著改进。

Reduction of penetration and abrasion from materials such as glass fibers through the use of plasma nitriding in combination with PVD;
通过等离子氮化与PVD组合处理来降低玻纤等的渗透与磨损；

Reduction of deposits through the use of chemically unreactive coatings such as CrN, Multi-CrN or CrN-mod;
使用化学稳定的涂层CrN来减少材料堆积；

Reduction of sticking through the use of non-reactive coatings;
使用不起反应的涂层来减少粘着倾向；

Keep surfaces in good condition with high-hardness coatings.
使用硬质涂层来保持工作面处于良好状态。



Example: Economic efficiency of coating an extrusion screw by PVD
Calculation period: 6 years

Polymer Processing / Coating References 聚合物加工 / 涂层推荐

Processed material 加工材料	ab. 简称	Problems 生产中存在问题	Solution 推荐涂层
Polyethylene聚乙烯	PE	Adhesion粘模	Maxit®TiN / Maxit®CrN
Polycarbonate聚碳酸酯	PC	Deposits / Adhesion材料堆积/粘模	Maxit®TiN
Polystyrene聚苯乙烯	PB	Adhesion粘模	Maxit®TiN
Polypropylene聚丙烯	PP	Adhesion粘模	Maxit®CrN
Polymethyl methacryalate聚甲基丙烯酸甲酯/亚克力	PMMA	Adhesion粘模	Maxit®CrN / Maxit®CrN-mod
Polyethylene terephthalate聚对苯二甲酸乙二醇酯	PET	Adhesion粘模	Maxit®TiN
Polyoxymethylene 聚甲醛	POM	Adhesion粘模	Maxit®CrN
Polyurethane聚亚安酯	PUR	Adhesion粘模	Maxit®CrN-mod
Poly ether ether ketone 聚醚酮	PEEK	Adhesion粘模	Maxit®CrN-mod
Elastomers弹性体, 人造橡胶	TPE	Adhesion粘模	Maxit®CrN-mod
Polyamide聚酰胺,尼龙	PA*	Abrasion / Corrosion磨损/腐蚀	Maxit®Multi-CrN/Maxit®CrN-mod
Alkylbenzenesulfonate丙烯腈-丁二烯-苯乙烯	ABS*	Abrasion / Corrosion磨损/腐蚀	Maxit®Multi-CrN/Maxit®CrN-mod
Polyvinylchloride聚氯乙烯	PVC	Abrasion / Corrosion磨损/腐蚀	Maxit®Multi-CrN/Maxit®CrN-mod
Polyvinylidene Difluoride聚偏氟乙稀	PVDF	Abrasion / Corrosion磨损/腐蚀	electroless Ni + Maxit®CrN
* often reinforced with glass fibers			

Solutions for Metal Forging and Stamping Dies
金属锻造及冲压模具解决方案

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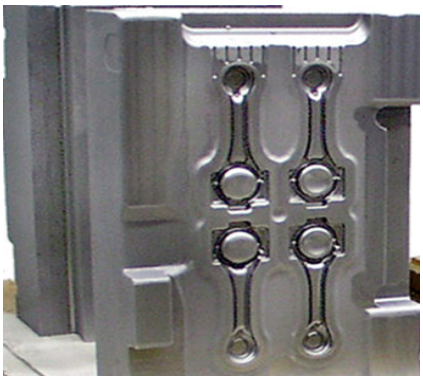
Coining die, reduction of wear and sticking using a Maxit® CrN-mod coating .
采用Maxit® CrN-mod涂层的硬币冲头，可以有效解决磨损和材料粘附的问题。



Forging dies for the manufacture of connecting rods, plasma nitrided and Maxit® CrN coated for abrasion resistance
连杆锻压模具经过离子氮化与Maxit® CrN涂层可以减少磨损。

Reduced lubricant requirements and improved service life by polishing and application of a Maxit® CrN coating
通过抛光和Maxit® CrN涂层可以减少润滑剂的使用和延长使用寿命

High stress, friction between die and material, sticking and cold welding are the main factors that affect the quality and service life of metal forming and blanking dies. **Polishing and Maxit® coatings** are good solutions to solve these problems in mass production.
高应力，材料流动摩擦，材料粘结，冷焊是影响金属成型模具质量稳定和寿命的主要因素。抛光与PVD涂层是解决上述生产中问题的有效途径。

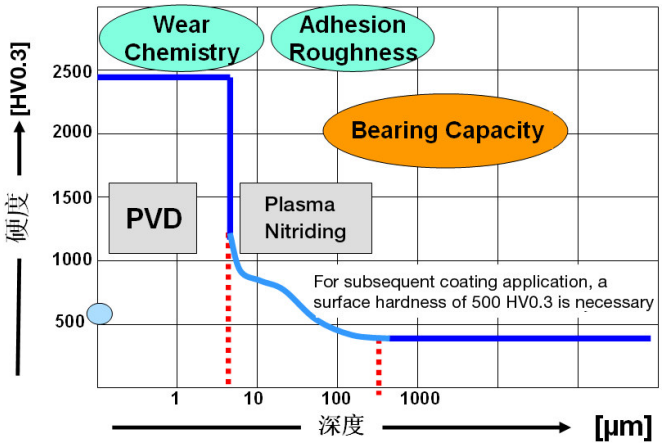
Abrasive wear protection using a high-hardness coating;
通过涂层的高硬度来减少工作面的磨料磨损；

Reduction of chemical reactions between tool and material;
减少模具与加工材料之间产生化学反应；

Reduction of cold welding;
减少冷焊倾向；

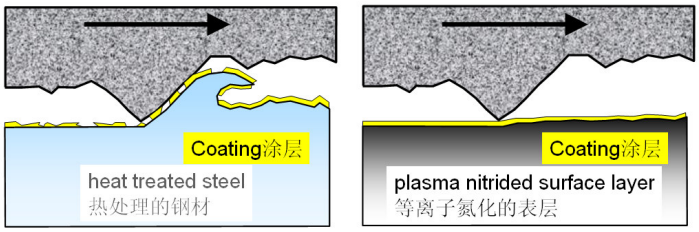
Perfect surface quality;
保持工作面处于理想状态；

Lower lubricant consumption using low friction coatings.
通过低摩擦系数涂层来减少润滑剂的消耗



离子氮化和**PVD**涂层后硬度的变化

Substrate Material and Coating Strength
基体材料的强度与涂层的关系



A harder surface layer provides better support for the coating
硬度更高的表层会对涂层提供更好的支持

Solutions for High-Pressure Die Casting Moulds
压铸模具解决方案

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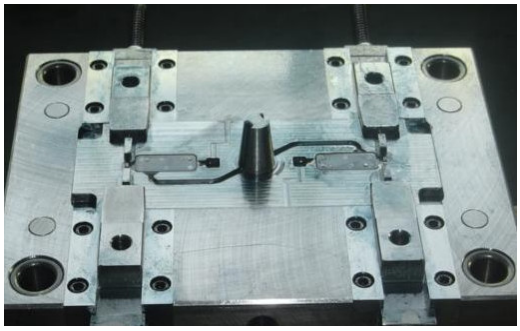
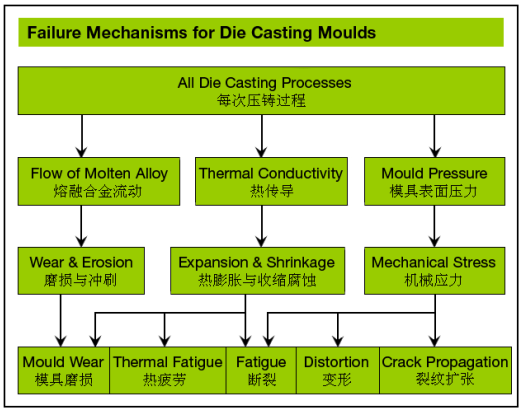


Problems: The primary stresses to which the surface of the mould is exposed are **thermal shock, abrasion and chemical reactions** between the liquid alloy and the iron in the steel mould. Certain regions of the mould are subjected to especially **high stresses**. In particular, these include ribs and the near-gate sections, where abrasion occurs as a result of the high velocity of the molten alloy.
问题：压铸模具表面主要面临的问题有热冲击、磨损、液态合金与模具钢的化学反应等。某些地方还有高应力，特别是成型筋的部位和浇口部位，这些地方由于高速熔融合金流动易发生磨损。

Solutions 解决方案:
Material selection: requires high-temperature strength, toughness, hardness and wear resistance.
钢材选择：需兼具高温强度，高韧度，高温硬度和抗磨损；



Design: adopt a small chamfer to reduce adhesion, avoid sharp corners to reduce cracking, optimize molten metal flow to reduce erosion.
模具设计：选用小的脱模角度减少粘焊，避免尖角应力造成开裂，优化流道设计减少冲蚀。

Nitriding and oxidation: diffusion layer and oxidation layer improve resistance to molten metals, adhesion resistance and thermal cracking resistance.
氮化扩散层和氧化层：可以提高模具耐溶损性、耐过烧性、耐粘着性和耐热裂性。

Maxit® Coating: Ensures the maximum service temperature of the PVD hard layer exceeds that of the molten alloy.
Maxit®涂层：选用合适的涂层以避免高温失效。

Failure Mechanisms 模具失效模式	Cause Analysis 原因分析	Solutions 推荐方案
Thermal Fatigue and Cracking 热疲劳与龟裂	Alternating expansion and contraction as a result of heating and cooling 由于加热与冷却造成的交替膨胀与收缩	Nitriding and PVD coating can stop the propagation of small cracks 氮化加涂层组合处理方式能阻止模具表面微小裂纹的生长
	Crack initiation and propagation induced by thermal stress fatigue on the die surface 模具材料存在微小裂纹，热应力加剧裂纹生长	
Abrasion 磨损	High velocity of the molten alloy 熔融合金的高速流动	Hard coating provides wear protection 硬质涂层能保护模具表面耐磨损
Adhesion 材料堆积	Casting alloy adheres to the die surface 高温合金易粘着在模具表面	Small chamfer effectively 'wipes' and polishes build-up on the surface 设计小的脱模斜度能有效脱除材料堆积
Soldering 粘焊	Chemical reaction, interdiffusion, formation of intermetallic phases 熔融金属与模具钢产生金属化学层	Good finishing with PVD coating can avoid the formation of intermetallic phases 良好的抛光加PVD涂层能阻止金属化合层产生
Erosion 冲蚀	Direct injection in gate area, thermal and chemical shock 浇口部位直接注入，热化学冲蚀	Optimization of the runner design with a hard coating provides smooth flow and erosion protection 优化的流道设计和硬质涂层能使流动更平稳，避免冲蚀。

General Requirements for Tools to be Coated
对涂层模具的要求

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Materials that can be coated 可涂层材料

High-speed tool steels, hot and cold processed steels, stainless steels, annealed steels and carbides.
高速钢，热作钢冷作钢，不锈钢，退火钢和硬质合金。

Heat treatment 热处理要求

Heat treatment must be carried out in such a manner that the coating temperature(250 ° C – 500 ° C) does not result in loss of hardness, changes in part geometry or part dimensions. The hardness of the tools to be coated should not be less than that of uncoated tools.
热处理回火温度必须高于涂层温度（250 ° C到 500 ° C以上 ），以免造成硬度降低，形状或者尺寸发生改变。要求涂层的工具硬度要高于不涂层的工具硬度。

Tool geometry and design 模具结构

In order for the tool to be fixtured, there must a hole, thread or surface that can remain uncoated. Surfaces that must not be coated should be capable of being mechanically or physically masked.
为了装卡需要，模具上需要有孔，螺纹或者允许不涂层的面。要求不能涂层的面需要能用机械或者物理的方法遮盖。

Tools with internal contours (drilled holes, slots, etc.) can be coated. Depending on the geometry, the coating thickness may diminish with increased depth.
模具的内部轮廓（孔，槽等）也可以涂层。涂层的厚度会随着深度增加而减小。

Soldered and welded areas must resist temperatures of 600 ° C and must be free of air-bubbles, flux and cadmium. It should be noted that, during the coating process, which takes place over several hours in vacuum and involves temperatures of 400 ° C to 500 ° C, the strength of the soldered and welded areas will reduce. This also applies to solders which can be used under vacuum. Tools which have been repaired by welding must have been annealed under stress-free conditions.
焊接区域须能承受600度以上的高温，不能有气泡，焊剂和镉。需要注意的是在几个小时的真空和四五百度高温的涂层过程中，焊接区域的强度会降低。这同样适用于真空环境下的焊接。补焊的模具需要进行无应力退火。

Tools must not be clamped, glued or compressed. Blind holes and internal threads must be free from oxides and other forms of contamination. Cooling/tempering channels and runners must be open and clean. 模具不能夹住，胶合或压住。盲孔和内螺纹内不能留有淬火盐或其它形式的脏物。冷却水道和流道必须打开干净。

Tool surface condition 模具表面状况

The surfaces must be flat and smooth to bare metal. Ground surfaces must be free from machining defects. Cutting edges must be free of burrs. Spark-eroded surfaces should be have a fine finish and oxides removed. Surfaces must be free of swarf, wax, adhesives, paint and residues from chemical smelting, etc.
模具表面应平坦光滑。磨削表面不能有烧伤。刃口不能有毛刺。放电面应该精加工并去除氧化层。模具表面不能有塑胶屑，腊，胶带，油漆，化学残留等。

Delivery method, packaging 包装及运输

Tools must be packed to prevent external shipping damage, or from striking against each other.
The packing must also be suitable for return shipment of the tools. To protect against rust, the tools should be lightly coated with a water-repellent oil.
模具的包装应能避免受外力损坏或相互碰撞。包装还要能重复使用。模具需要防锈。

Sulzer Metaplas GmbH, Bergisch Gladbach, Germany
Am Böttcherberg 30-38, 51427 Bergisch Gladbach
Tel.: +49 2204 299-0
Fax.: +49 2204 299-266
Email: metaplas@sulzer.com
www.sulzermetco.com

Sulzer Metco Surface Technology (Shanghai) Co. Ltd.,
苏尔寿美科表面技术（上海）有限公司
666 Min Bei Road, Minhang, Shanghai 201107 P.R. China
中国上海闵行区闵北路666号
Tel.: +86 21 5226 2000
Fax.: +86 21 5226 4701
Email: smcn.shanghai@sulzer.com
www.sulzermetco.cn