

高效切削刀具参数特征

ISCAR CHINA 吴江

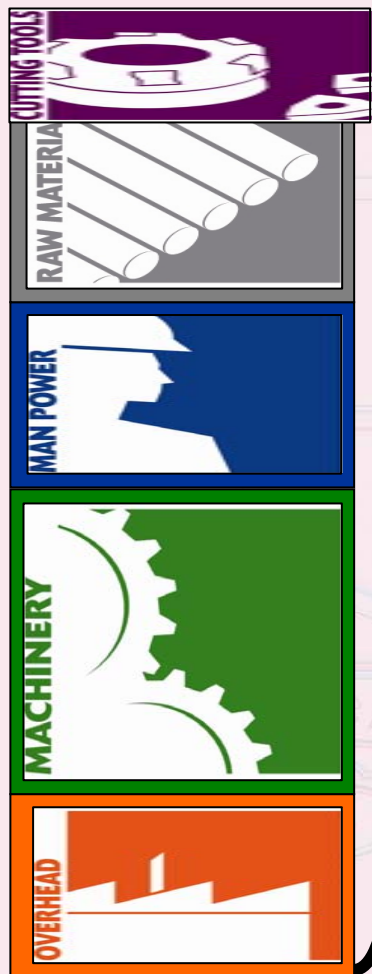




高效加工 (HPC High Performance Cutting) 背景

Price, Tool Life or Productivity?

价格, 刀具寿命, 生产率?



Actual Production Cost
实际加工成本

Price 价格
Decreased Price 降低价格

Tool Life 刀具寿命
Increased Tool Life 提高刀具寿命

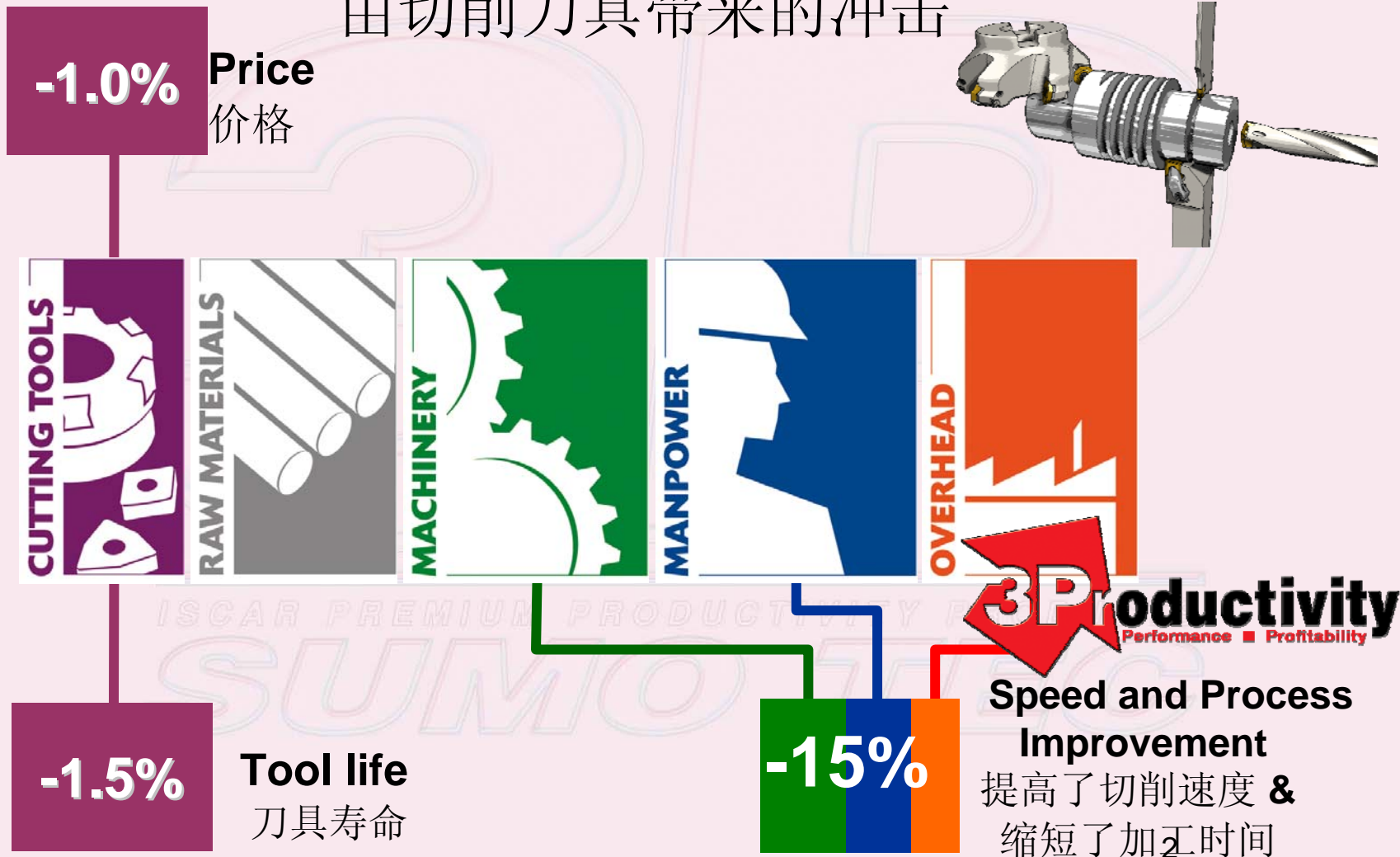
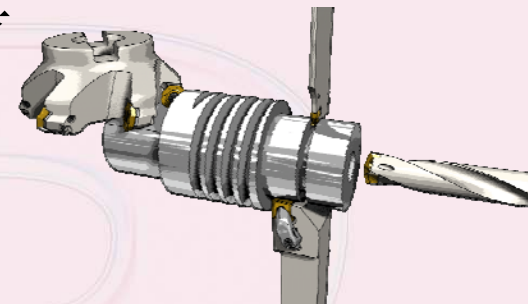
Productivity 生产率
Increased Cutting Speed and Improved Process 提高切削速度 缩短加工过程



发展速度和发展成本---高效加工 (HPC)

The Impact of Cutting Tools

由切削刀具带来的冲击



什么是高效切削 (HPC) ?

High Performance Cutting

HPC切削被描述为能满足提高金属去除率要求的切削加工，与传统的加工技术相比，要提高效率200%到500%。

High Speed Cutting

高速切削 (HSC) 一直都被认为是高速生产加工的同义词。



HPC与HSC (High Speed Cutting)

- 加工的目的主要是使金属去除率达到最大：由于事实上无论增加轴向或径向进给来加工3D曲面，都会严重地受到技术上的制约，要想提高加工率，就只有借助于增加切削速度了。然而，还会有HSC技术上的制约。
同时增加轴向和径向的吃刀量，以及增加进给速度，应该能够对提高加工效率有所帮助。
- HPC的焦点是优化切削效率，以获得最大的材料去除率。与HSC不同，HPC既产生很大的切削力矩和功率，允许较大的吃刀深度。HPC也不同于传统的大余量切削，在大余量切削方式下，是单一指标，而HPC强调的是综合指标。
- HPC策略则更侧重于全过程，力图循环时间最小化。
- 更广义的解释就是，HPC这一名词还意味着对整个加工工艺链进行优化。



HSC-HPC机床

(1)机床结构的刚性

高速加工要求提供高速进给的驱动器(快进速度约60m/min,3D轮廓加工速度为10m/min),能够提供0.6m/s²到10m/s²的加速度。高效加工要求机床具有更好的刚性。

(2)主轴和刀柄的刚性

高速加工要求满足10000r/min到60000r/min的转速,通过主轴压缩空气或冷却系统控制刀柄,主轴间的轴向间隙不大于0.0002英寸。

(3)可靠性与加工工艺

能够提高机床的利用率(6000h/y)和无人操作的可靠性,工艺模型有助于对切削条件和刀具寿命之间关系的理解。拥有完善的机床测量功能以保证其加工精度以及完善的机床自检和保护功能。

(4)合理的刀库容量、合理的输出功率及扭。

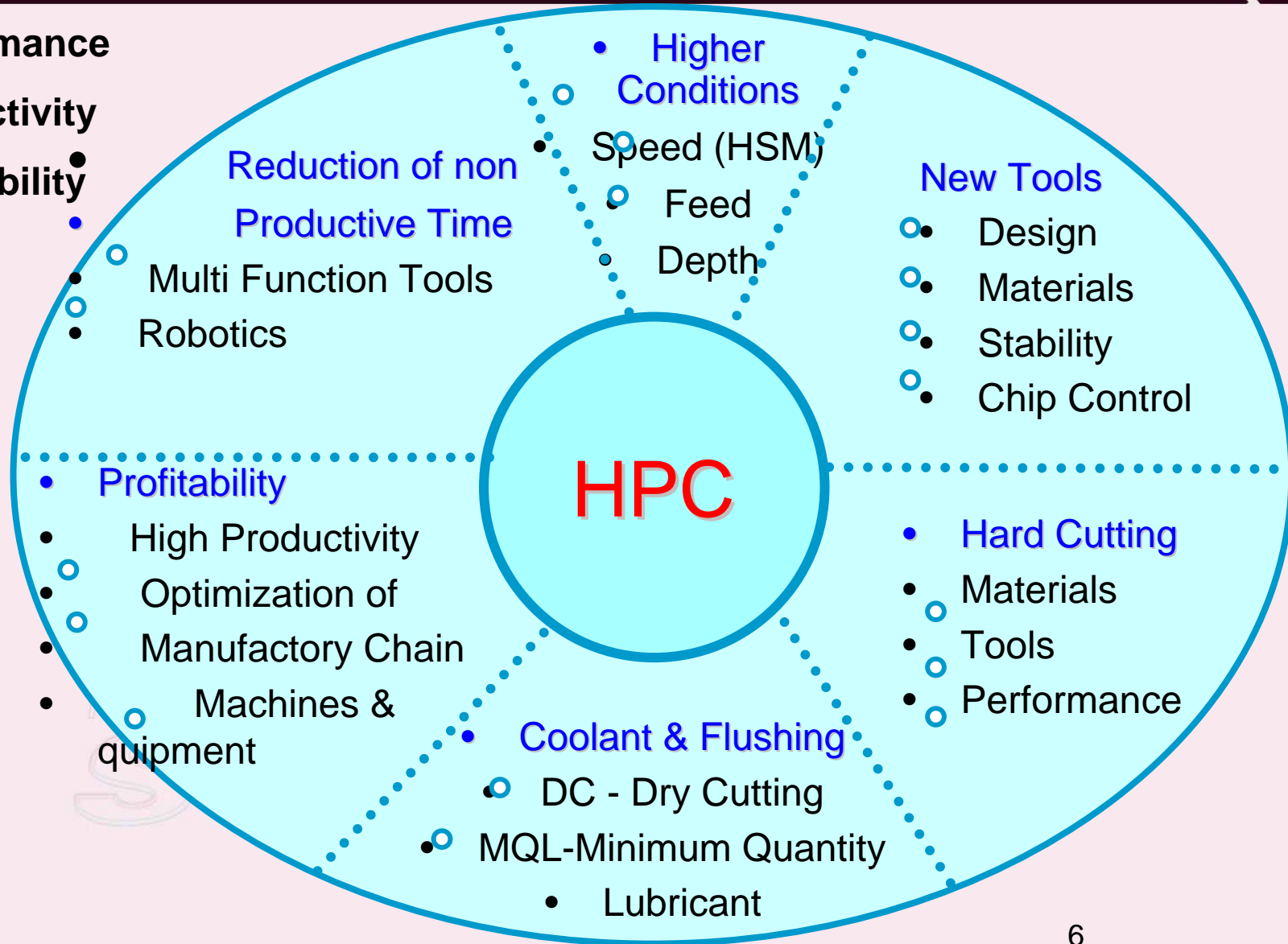


High Performance Cutting

■ Performance

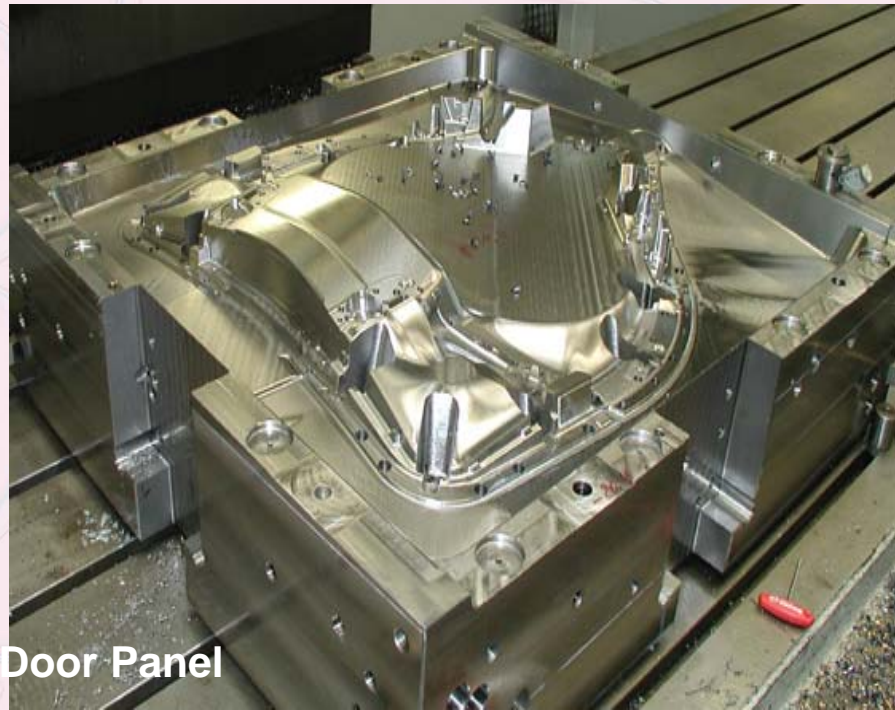
■ Productivity

■ Profitability



高效切削刀具几何参数--案例

这个任务涉及到宽1500mm、长1500mm、厚430mm及硬度HRC36-40的P-20模具钢的粗加工。模具的设计上需要在粗加工时切除超过2000kg的材料。为了完成这个重载粗加工任务，需要大量时间和资源。



Door Panel

Dimension 1500x1500x430
Mat. 1.2738



HPC案例

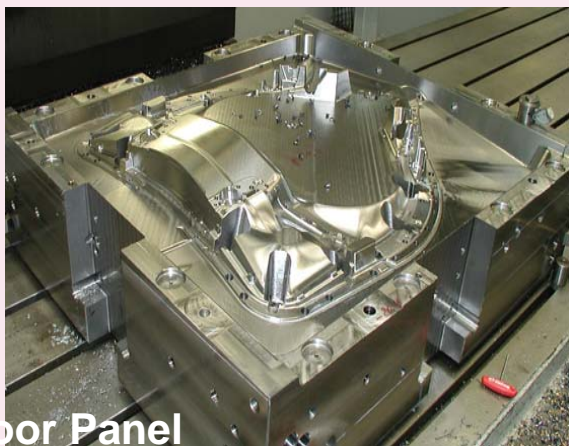
使用直径100的圆刀片铣刀用于粗加工。刀片的每个切削刃通常仅能连续加工约15分钟，对于淬硬的P-20工具钢的加工参数为切深1mm、进给速度约为1000mm/min

解决方案一是用D100的仿形铣刀。使用IC908牌号的刀片，在转速450 rpm、切深1.5mm时获得了1650 mm/m的进给速度。使用这把铣刀时，每个切削刃的刀片寿命一个小时，为原来的四倍。





Metal Removal Rate

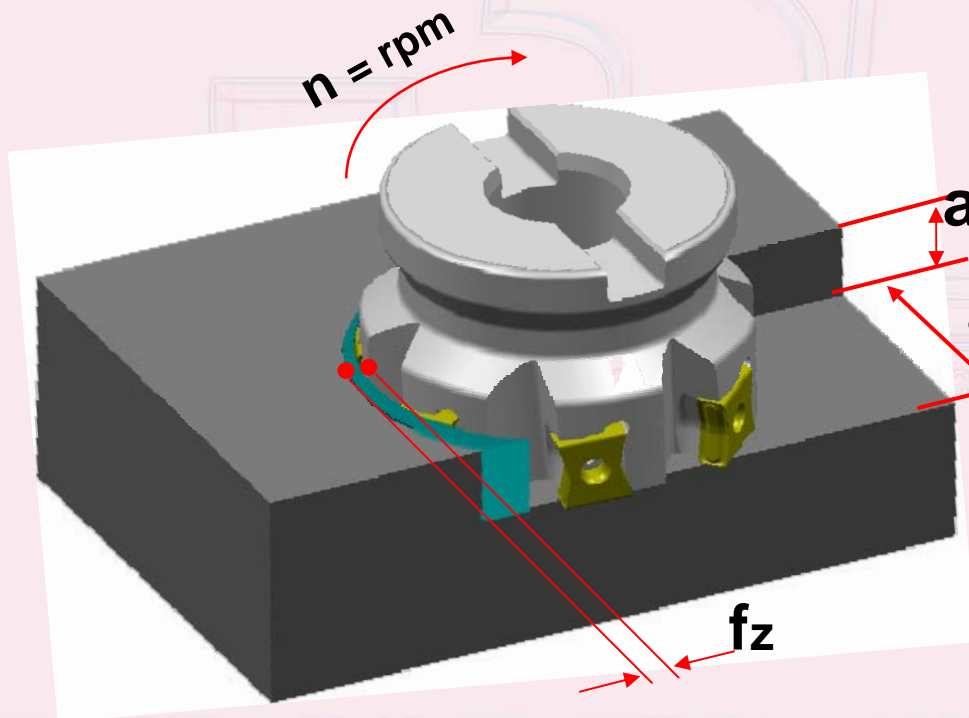


Door Panel



$$Q = a_e \times a_p \times n \times f_z \times z$$

Q = Metal Removal Rate $\frac{\text{mm}^3}{\text{min}}$ $\frac{\text{Cubic in}}{\text{min}}$



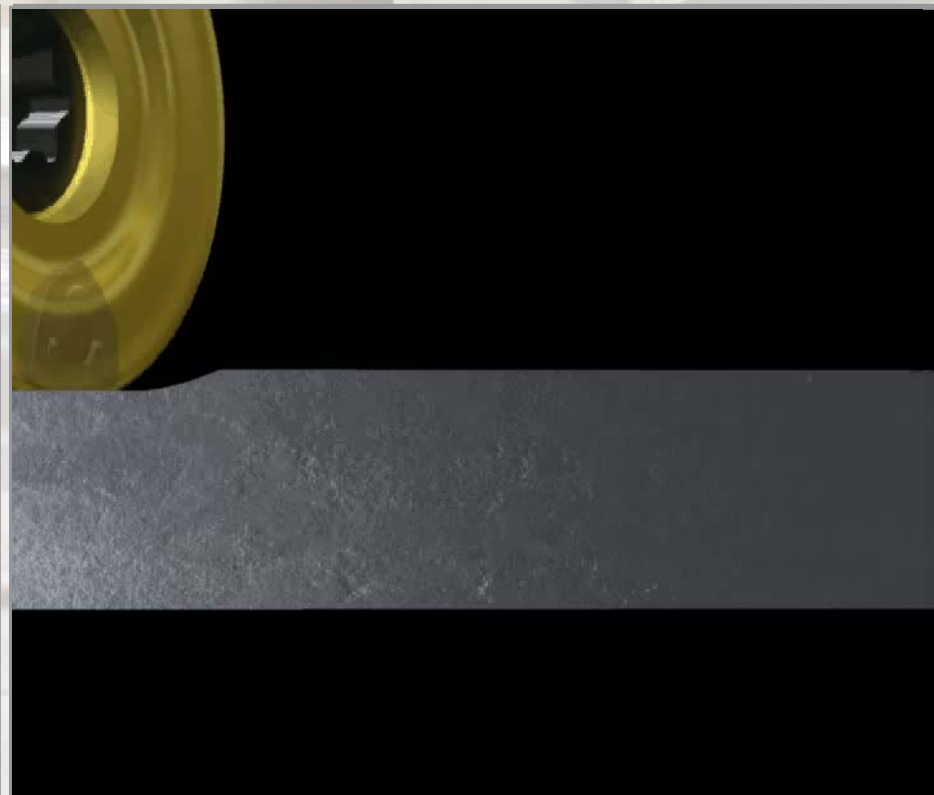
HPC切削实践—小主偏角Kr

FEEDMILL



方案二

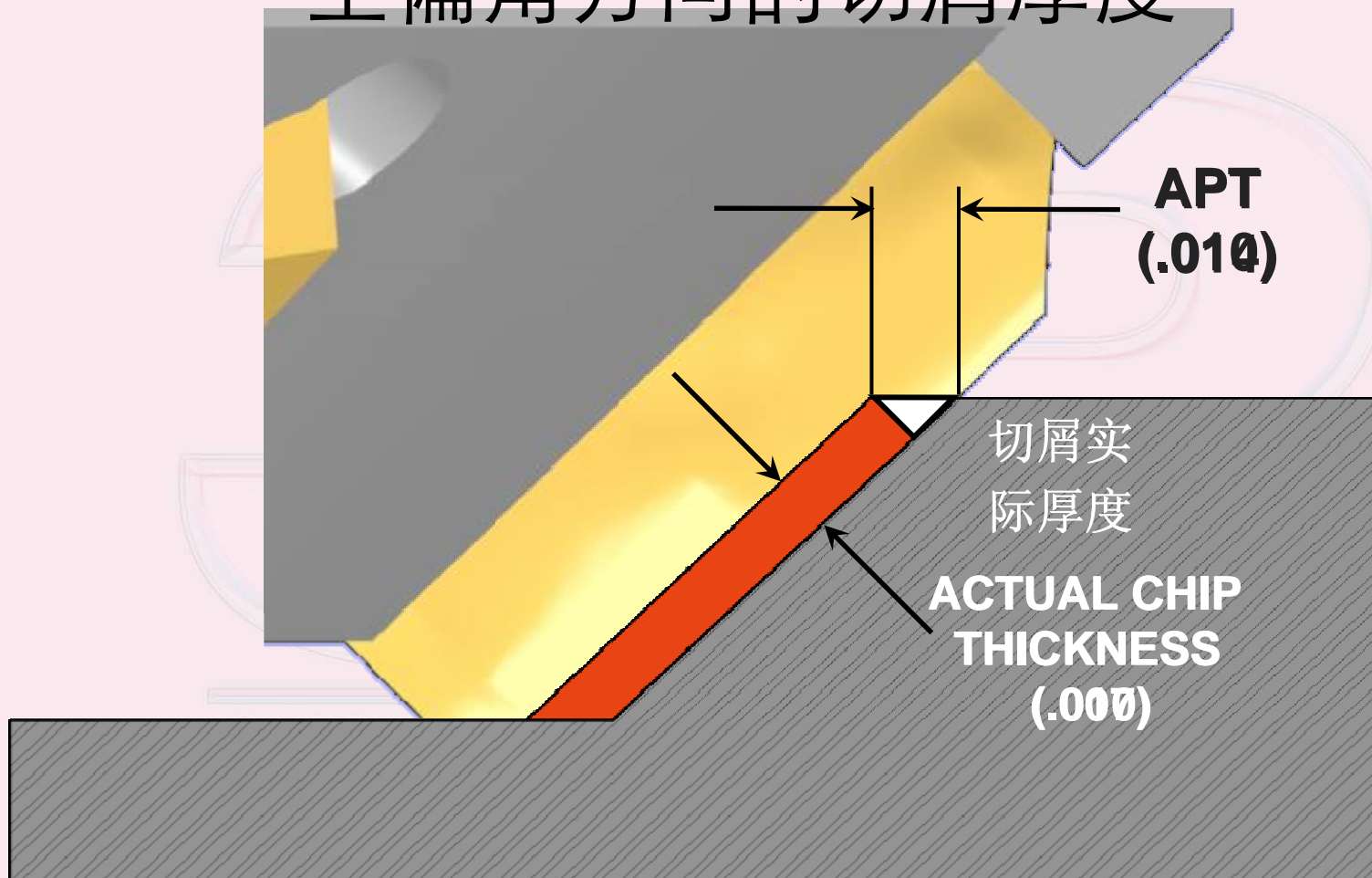
使用装一种特殊形状的三角形刀片的铣刀，它能承受高达每齿3.5mm的进给量。切削力沿轴向作用到主轴上，即使加工时有长的悬伸也有助于提供稳定性





Lead Angle Chip Thinning

主偏角方向的切屑厚度



Chip Thickness Factor
 $CTF = \text{Cosine of the lead angle}$

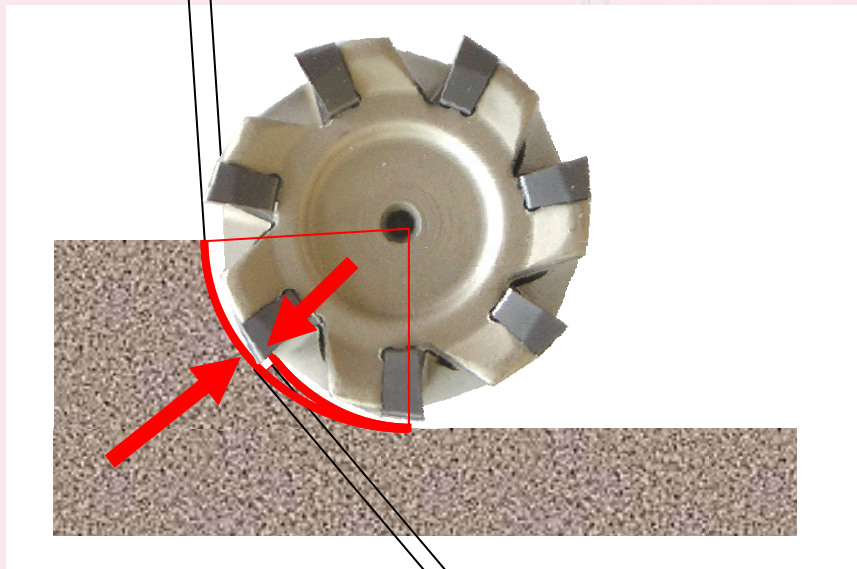
Mean chip thickness h_m – Basic terms

平均切屑厚度 h_m – 基本术语

Since the chip thickness h changes constantly as the cutter is milling into the material, it is essential to calculate the mean chip thickness as a numerical value! 由于铣削加工中, 切屑厚度 h 持续变化, 非常有必要计算出切屑厚度平均值作为参考!

This value gives an indication of: 切屑平均厚度暗含以下信息:

h_{max}



the load on the insert

刀片负载

the chip formation at the cutter

刀具断屑槽

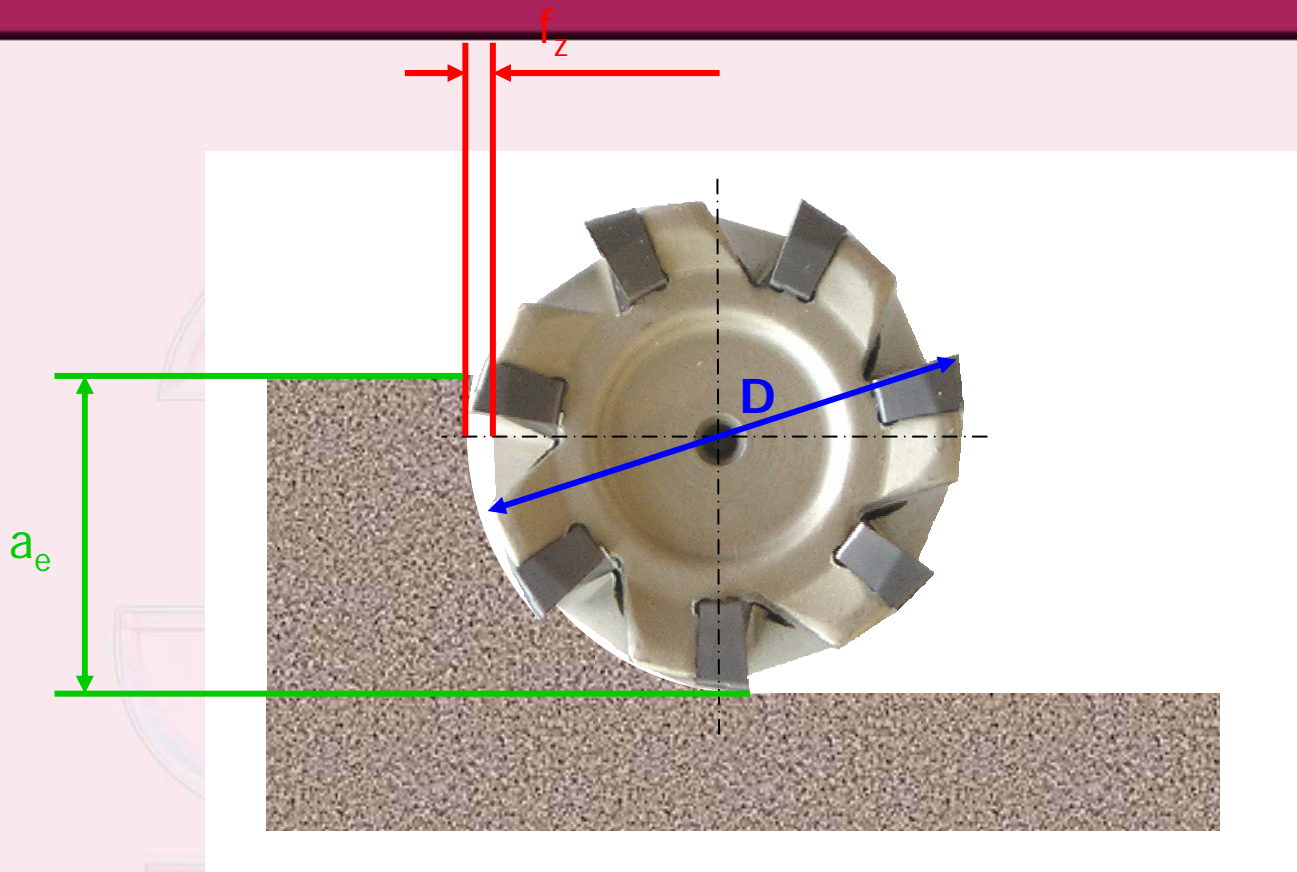
the estimated power demand

功率预估

h_m



基本术语—切宽比率

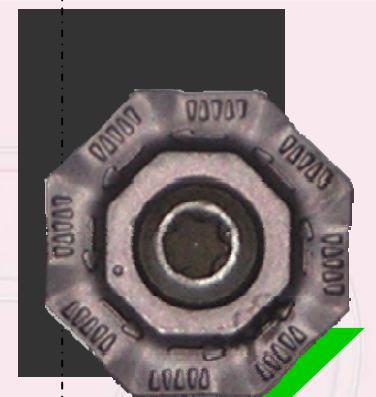
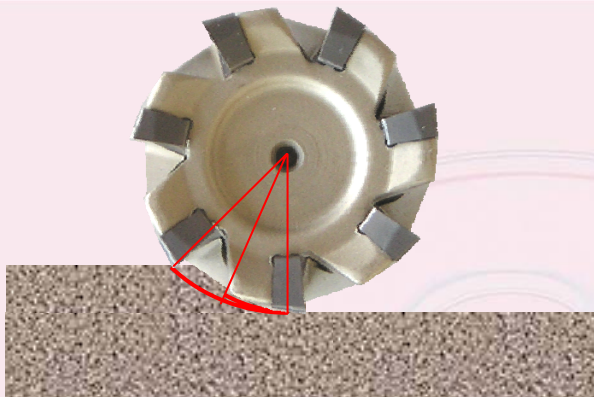


ISCAR PREMIUM PRODUCTIVITY PRODUCTS

$$\text{Cutting ratio } E\% = \frac{a_e}{D} \times 100 (\%)$$
$$\text{切宽比率 } E\% = \frac{a_e}{D} \times 100 (\%)$$

Mean chip thickness and Chip thickness

切屑平均厚度 & 切屑厚度



- prevents underloading the cutter
- 避免刀具负载不足
- for cutting depth ratios less than 33%
- 切深比率小于 33%

- maximum load on cutter 铣刀最大负载
- generally for cutting depth ratios greater than 33%
- 通常切深率大于 33%

$$f_z = h_m \times \frac{D \times \pi \times \phi_e}{a_e \times 360 \times \sin K}$$

$$\sin 90^\circ = 1$$



Metal Removal Rate Q

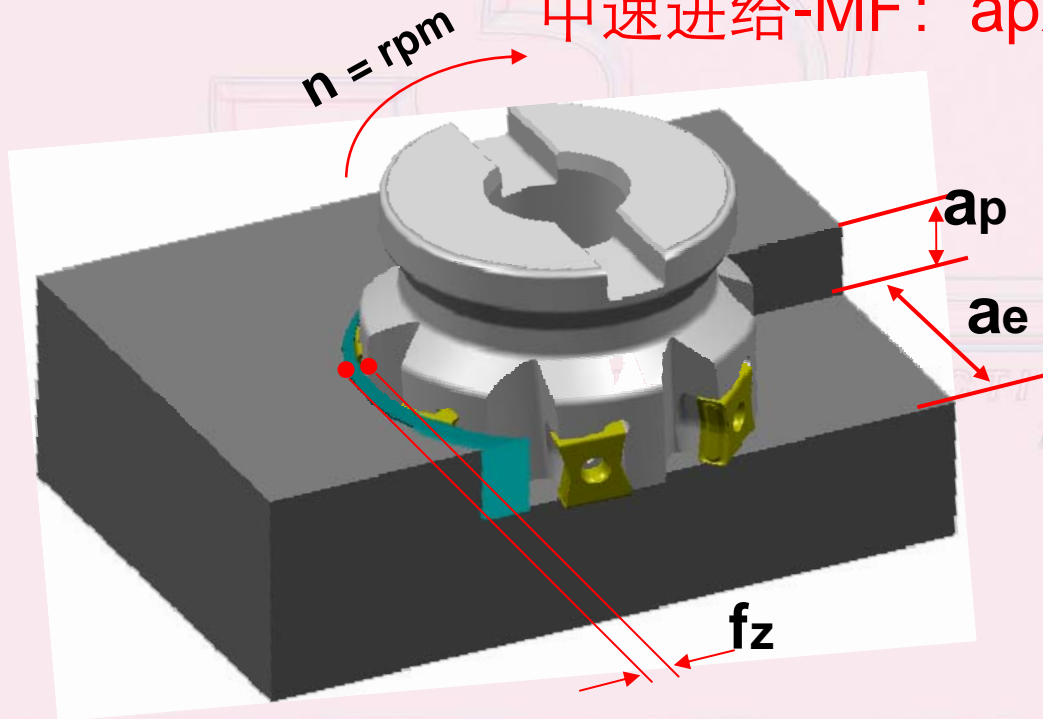


$$Q = a_e x a_p x f_z x z x n$$

$$a_p \times f_z$$

快速进给-FF: $a_p x f_z = 2 \times 3.5 = 7$

中速进给-MF: $a_p x f_z = 3.5 \times 3 = 10.5$





MF 中速进给铣刀

(中速进给)

**NEW
PRODUCT**

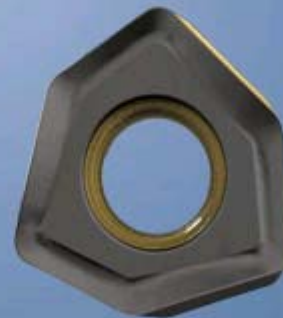
**NEW
PRODUCT**



MF 中速进给铣刀



H600-08





HELIDO
600 UPFEED LINE

MF-直径范围50-160

使用标准H600 系列刀片





Main Frame Base Face Milling

Competitor

Material removal rate

204 cm³/min

ISCAR

864 cm³/min

HELIOCTO





CHATTERFREE
SOLID MILL LINE

防振降噪立铣刀

不等螺旋角不等齿距铣刀 ---防振降噪立铣刀



Variable Pitch Eliminates Vibration in Deep Roughing Applications

深腔粗铣应用, 不同齿距免除了震颤

20 - 30% Less Power Consumption 功率降低 **20 - 30%**

Suitable for Low Power Machines 可用于低功率机床



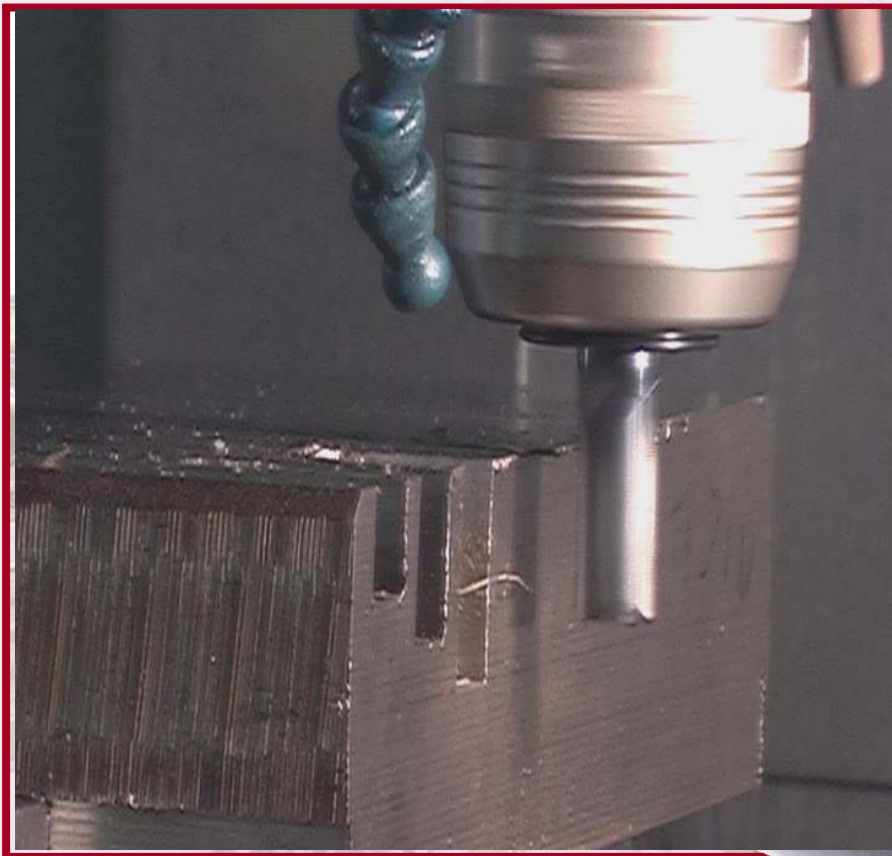
EC.....CF Chatter Free

DMU 80T P:

Test Report

15 kW ISO40

Aisi. 304 1.4301 不锈钢



Item Competitor EC....16...CF

Vc:		
m/Min/sfm	100	100
Z =4T	4	4
Fz: mm/t	0,05	0,05
Ap: mm	16	32
Ae: mm	16	16
Q: cm ³ /min	cm ³ /min102	cm ³ /min204



不等螺旋角不等齿距铣刀 ---防振降噪立铣刀



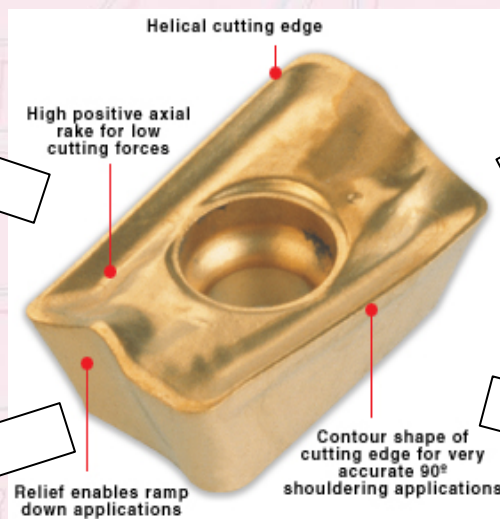
可用于粗加工及精加工,减振效果明显。

在外冷的切削条件下,可高速进行全槽铣,切深分别可达: **2xD & 4xD**

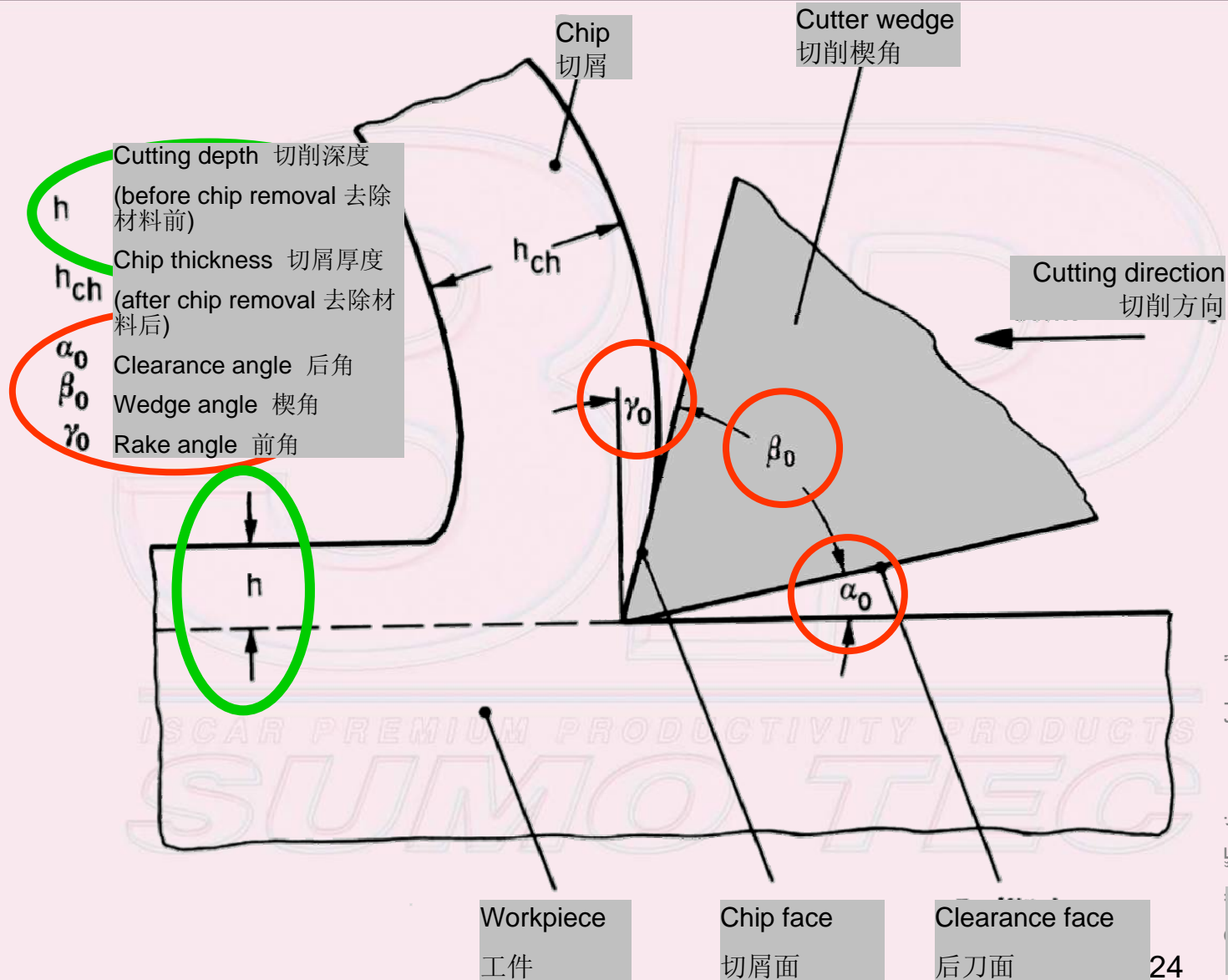
切削功率低,即便夹持于 **ISO40** 及 **BT40** 刀柄,也可提高金属去除率并减振。在许多的铣削应用中,在最大化金属去除率的同时,可缩短加工周期。

抛光的刀具表面,加工底平面光滑,侧壁无接刀
高速切削时刀具寿命高
直径范围: **3-25 mm**

帶前角帶螺旋刃的銑削刀片



Machining angles 工作角度



Source: "Fertigungsverfahren"

Dominant Parameters For Cutting Edge Design 切削刃形特征

Cutting angle

楔角

Land

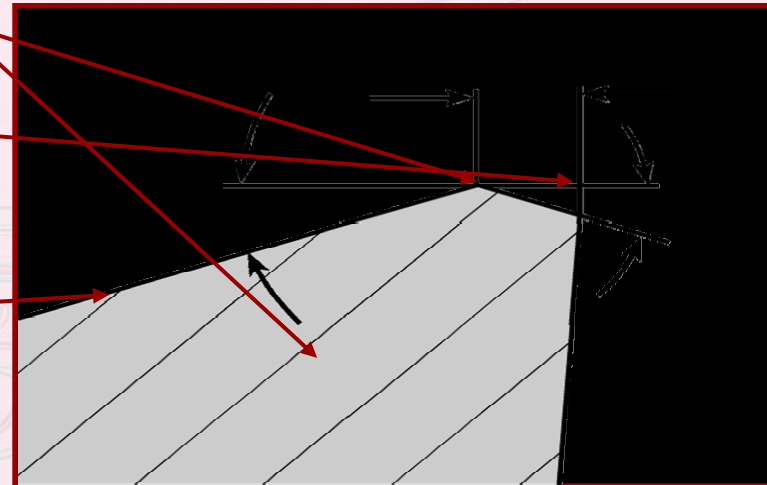
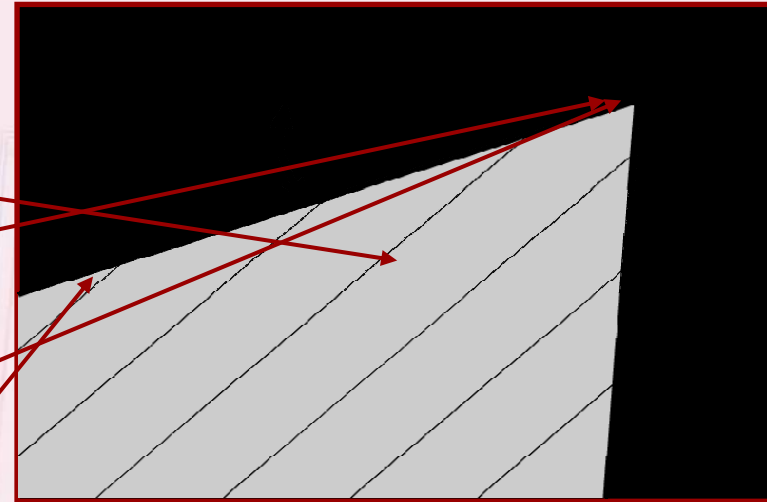
倒棱

Honing

钝化

positive design

前角



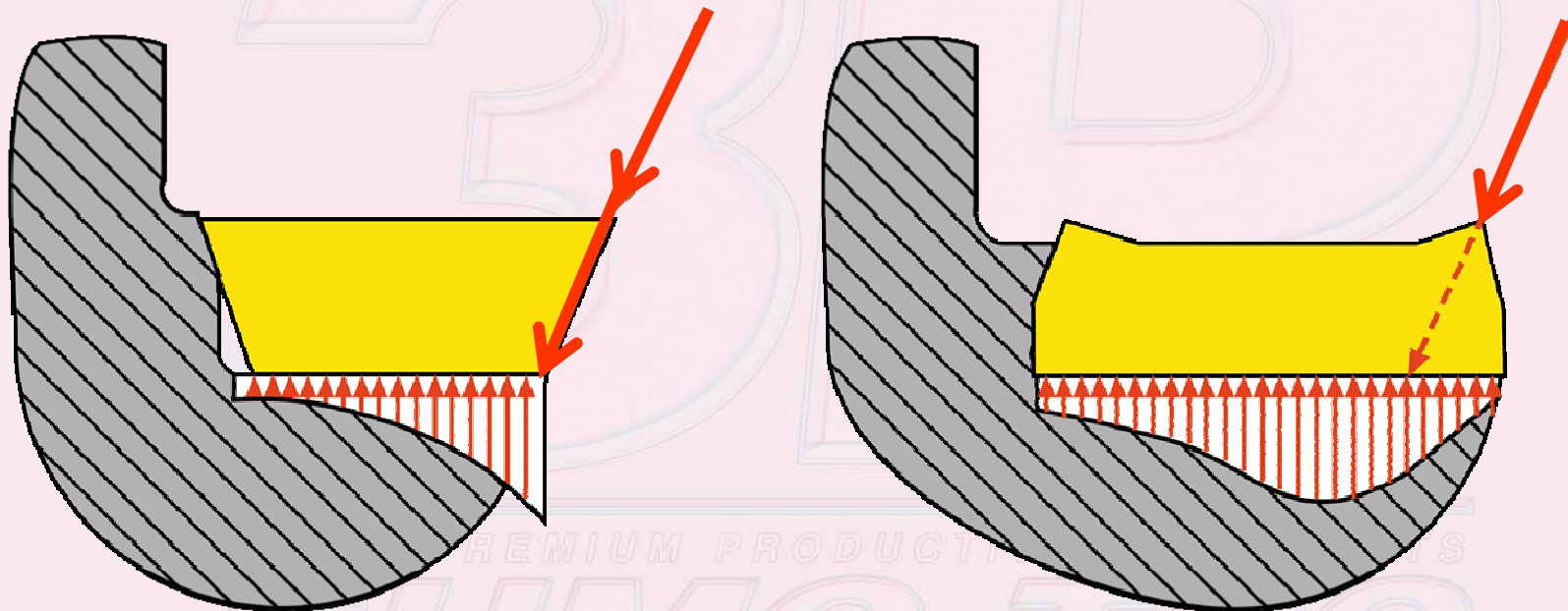
Advantageous positive design with the required toughness

有利的几何参数设计，刀片强与锋利兼顾



Cutting Force Distribution

- **Conventional**



- • **Cutting force alignment**
- • **Bottom of insert is wider then it's top**



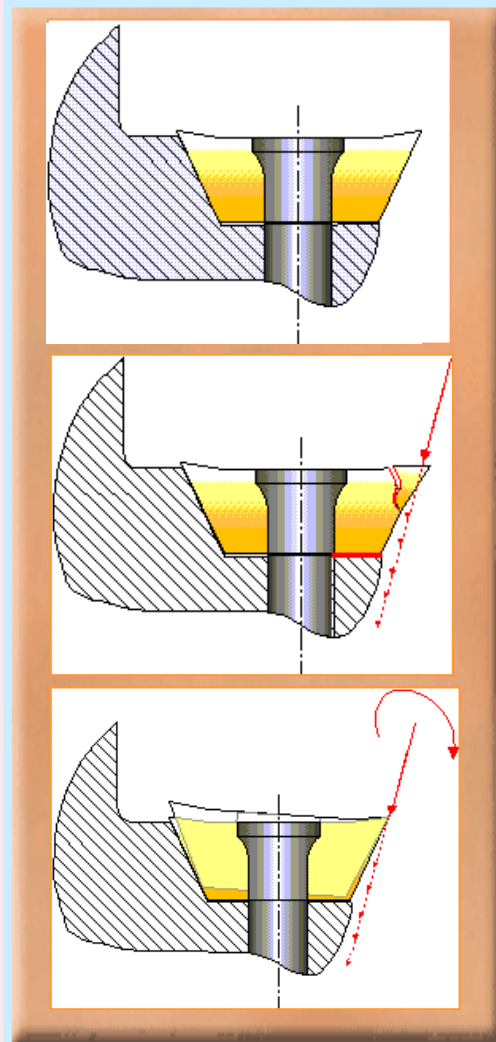
Mill 2000

The Millennium Line

- The line that will improve
- productivity with a high
- metal removal rate

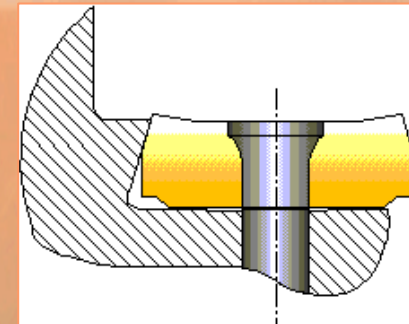


Existing Method Vs.

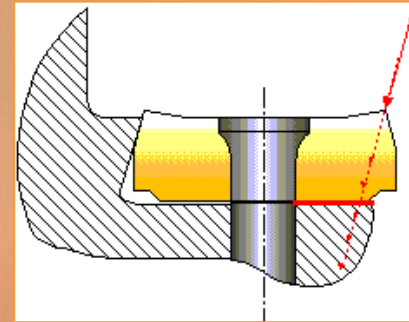


- Existing
- Method

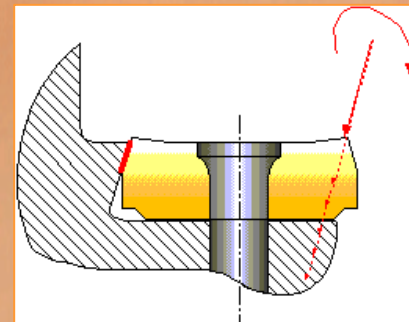
Mill 2000



- Stronger
- cutting edge
- Better support



- Wedge shape
- No rotation
- Stronger pocket



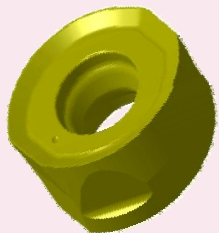
bein

Bein 3145552
H400 PR D38A50-06-22-10

HELIDO
ROUND H400 LINE



- ✓ 双面刀片，4个长切削刃
- ✓ 燕尾形刀片定位，刚性极佳
- ✓ 密齿型设计，每转进给更大，效率更高
- ✓ 刀片厚，强度高
- ✓ 正前角，切削轻快

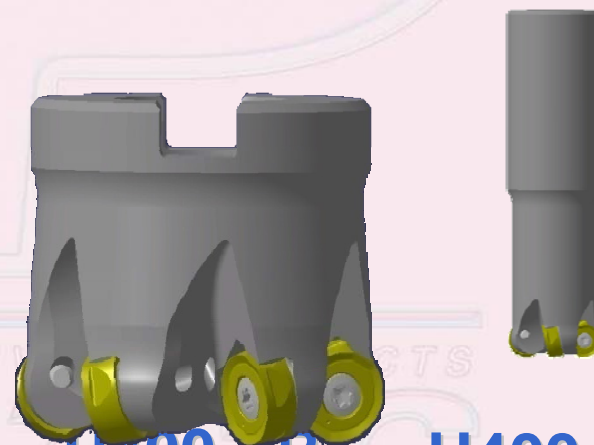


12 刀片 标准品设计以下三种断屑槽形

H400 RNHU 1205-HP

H400 RNHU 1205-ML

H400 RNHU 1205-AX



H400-FR

Ø 40-80

H400-ER

Ø 32



HELIDO

ROUND H400 LINE



H400 RNHU 1205-HP IC830\IC330
适用于难加工材料: 钛合金, 镍基高温合金



H400 RNHU 1205-ML IC830\IC808
适用于合金钢, 碳钢



螺旋刃刀片 适用于不锈钢 AISI 316,304
H400 RNHU 1205-AX IC830\IC808





TANGMILL Advantages

Radial Clamping



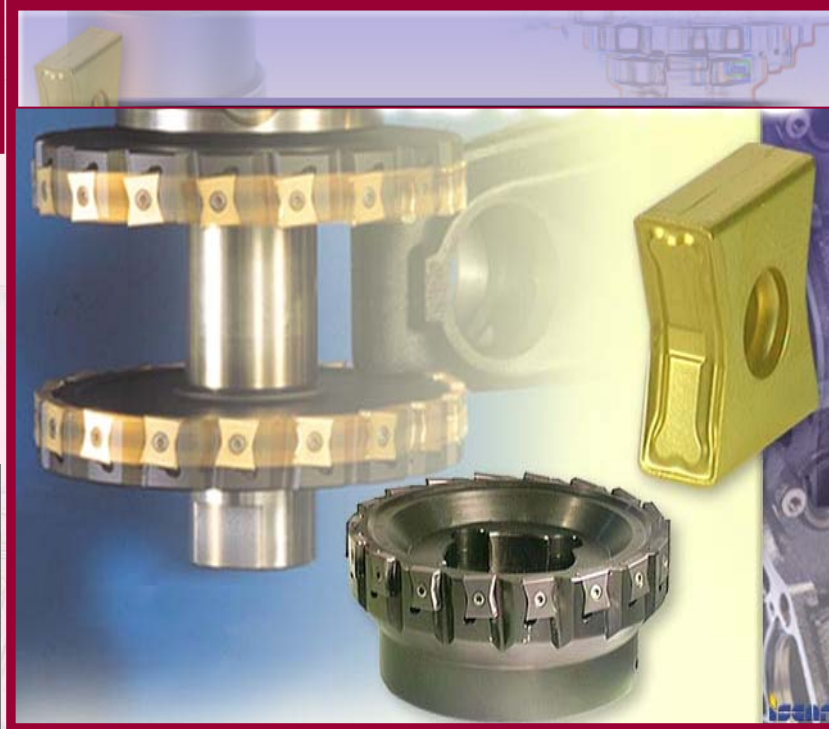
Competitor

Higher Fz,
Higher ap
More z

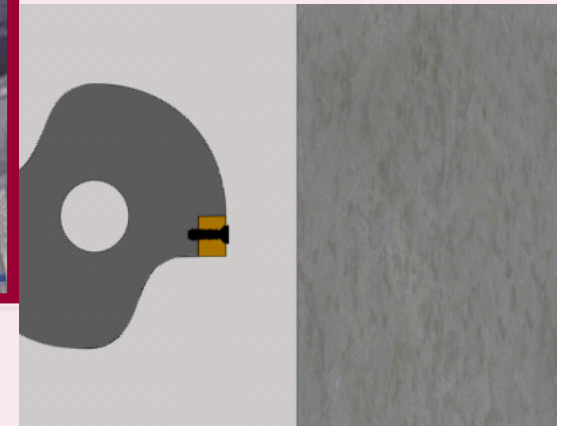
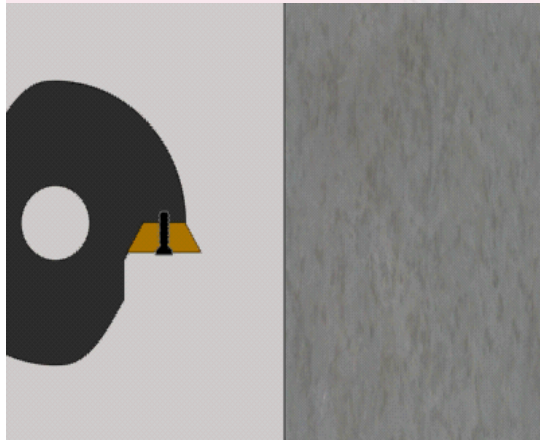
Tangential Clamping



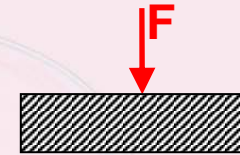
TANGMILL



TANGMILL Inserts



Ingersoll **MAX** line



Tangential concept

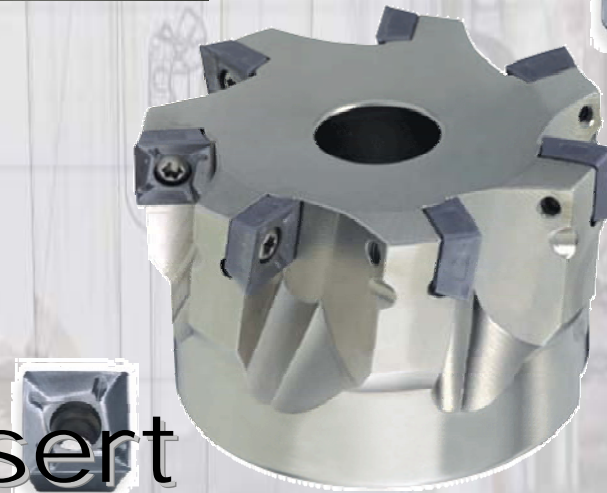
Tangential insert

Radial concept

radial insert

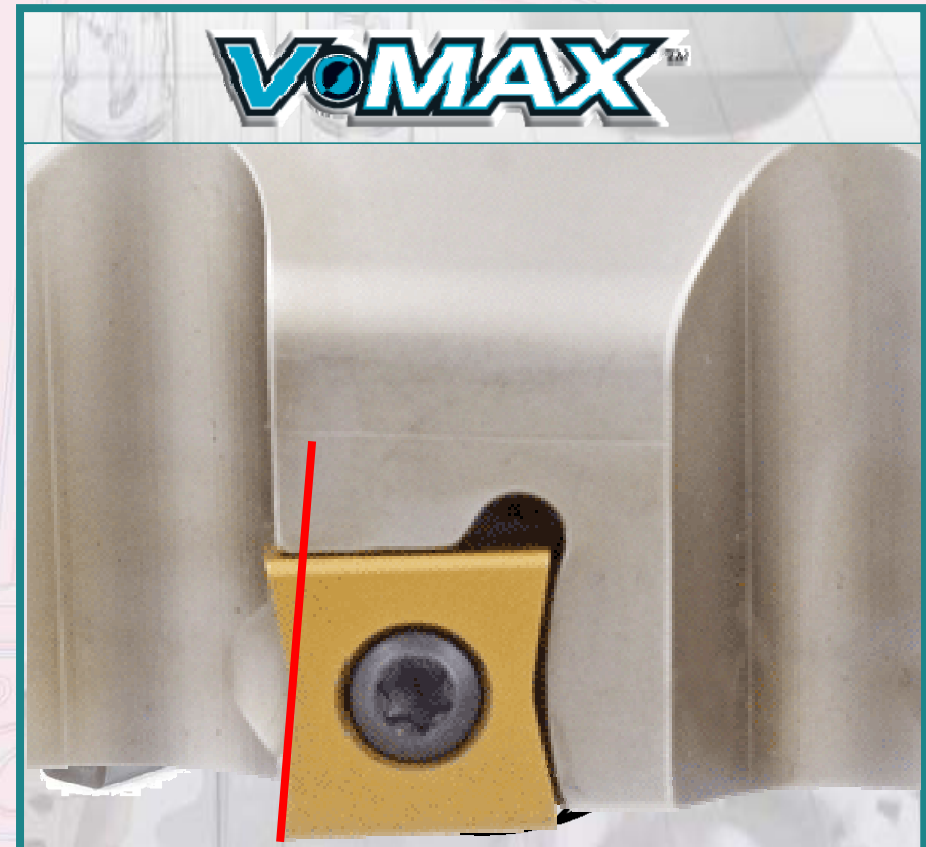
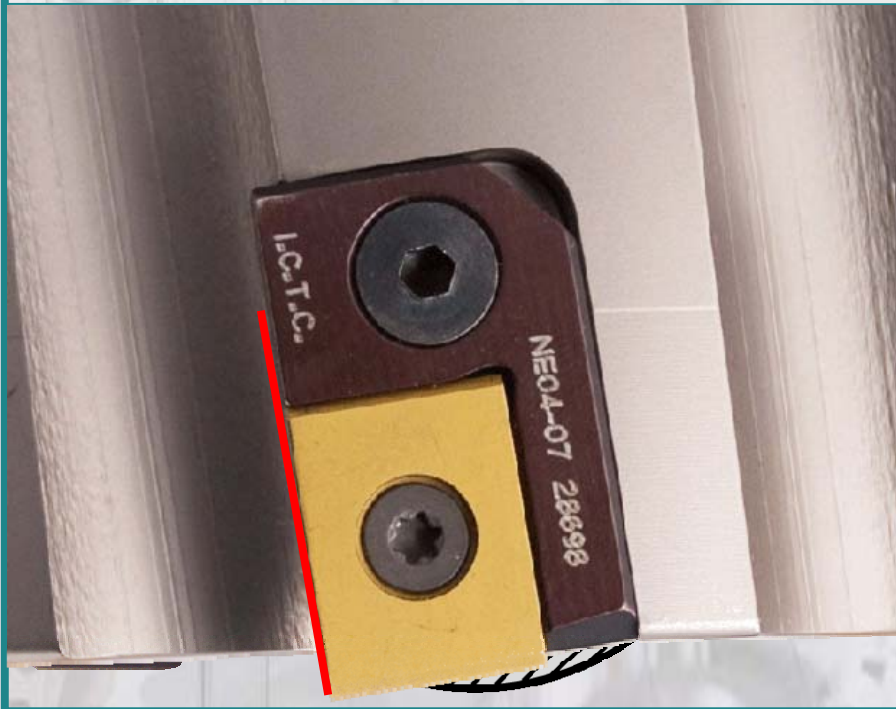


Strong Insert



VOMAX™ Advantage

Tangentiales Fräsen



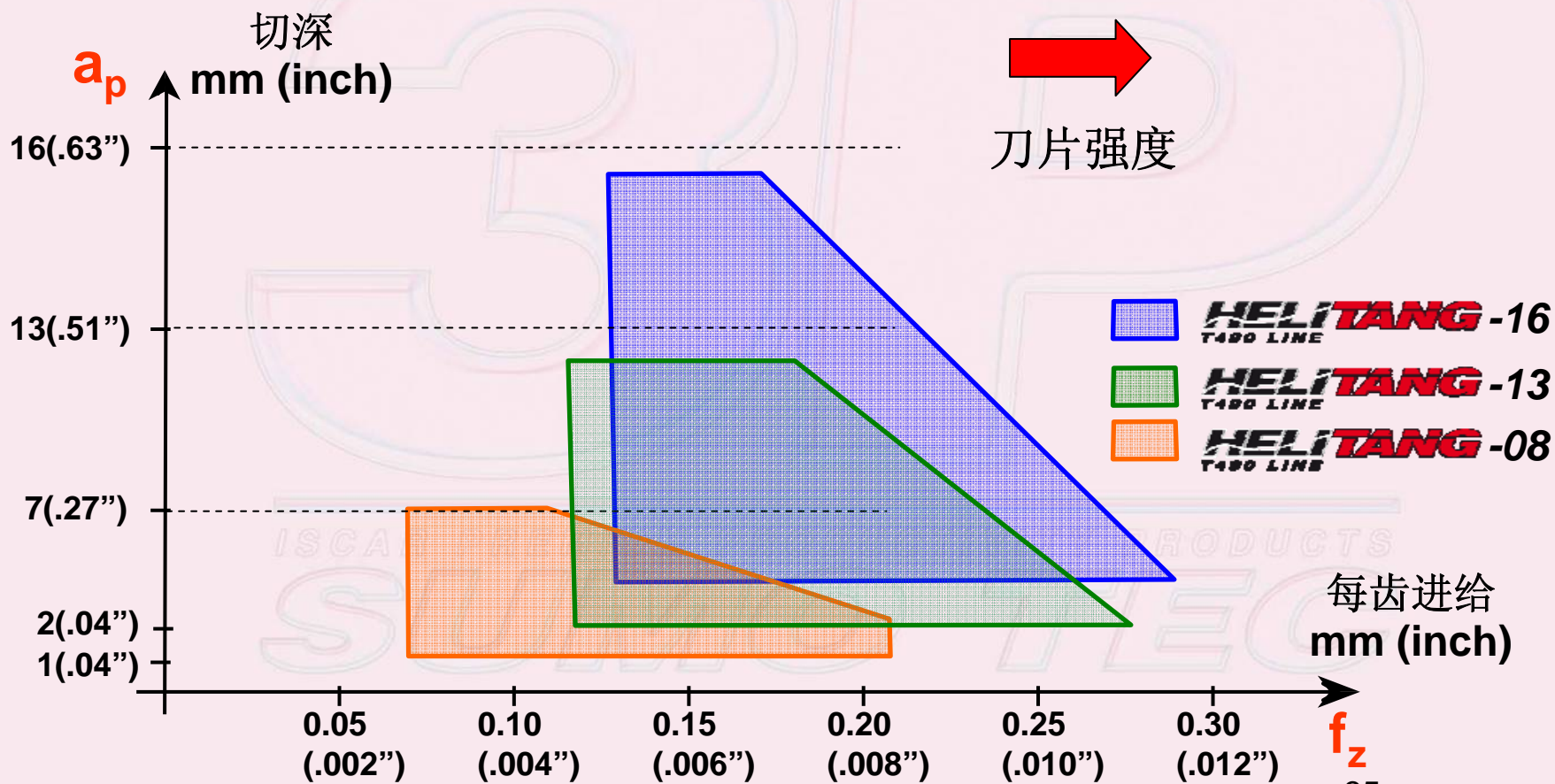
Strong Insert



ISCAR **M**ILL LINE

HELITANG T490 LINE

每齿进给量推荐



Rotor Hub



The hub is made of a cast iron case. It generally connects the three blade rotational assembly to a linear low speed shaft, which connects to the turbine's gearbox. Most modern turbine hubs contain a pitch system to adjust the angle of the blades by rotation of a bearing at the root of each blade, to control power and slow the rotor as required.



Face Milling
Range: Ø40 - 200 mm (Ø1.57 - 7.87")

HELDO
848 LINE

S845 SNMJ 1305... - square double-sided inserts with 8 cutting edges, or ONMU 0505... octagonal, double-sided inserts with 16 cutting edges. Enable highly efficient milling.

SUMO TEC
810
P M N S H



Helical Interpolation Rough Boring
Range: Ø20 - 80 mm (Ø.787 - 3.15")

HELTANG
7486 LINE

4 cutting corners, tangential geometry for Fast Metal Removal.

SUMO TEC
810
P M N S H

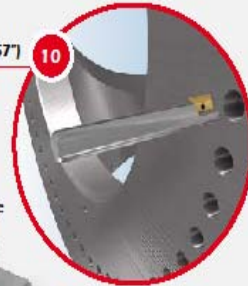
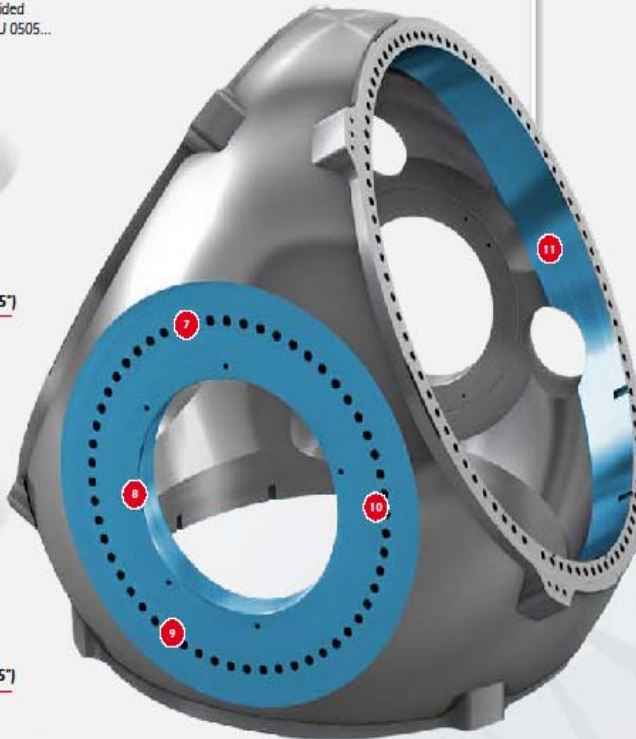


Drilling
Range: Ø12 - 80 mm (Ø.472"-3.15")

DR-TWIST
INDEXABLE DRILL LINE

These drills are designed with twisted coolant channels, which allow for a strong drill body with excellent resistance to torsion and very efficient chip evacuation.

SUMO TEC
808
P M N S H



Milling
Range: Ø12 - 40 mm (Ø.472 - 1.57")

MILLTHREAD

Enables internal thread milling and external qualitative precision threads on CNC machines by using a helical interpolation CNC program. MILLTHREAD thread milling cutters are available in addition to solid carbide thread milling cutters with indexable thread milling inserts for any standard thread profile.

928
P M N S H



Fine Boring
Range: Up to Ø2.1 meter (Ø82.67")

ITSBORE

The ITSBORE system TCH AL: Aluminum twin cutter heads for rough and fine boring operations.

SUMO TEC
5005
P M N S H

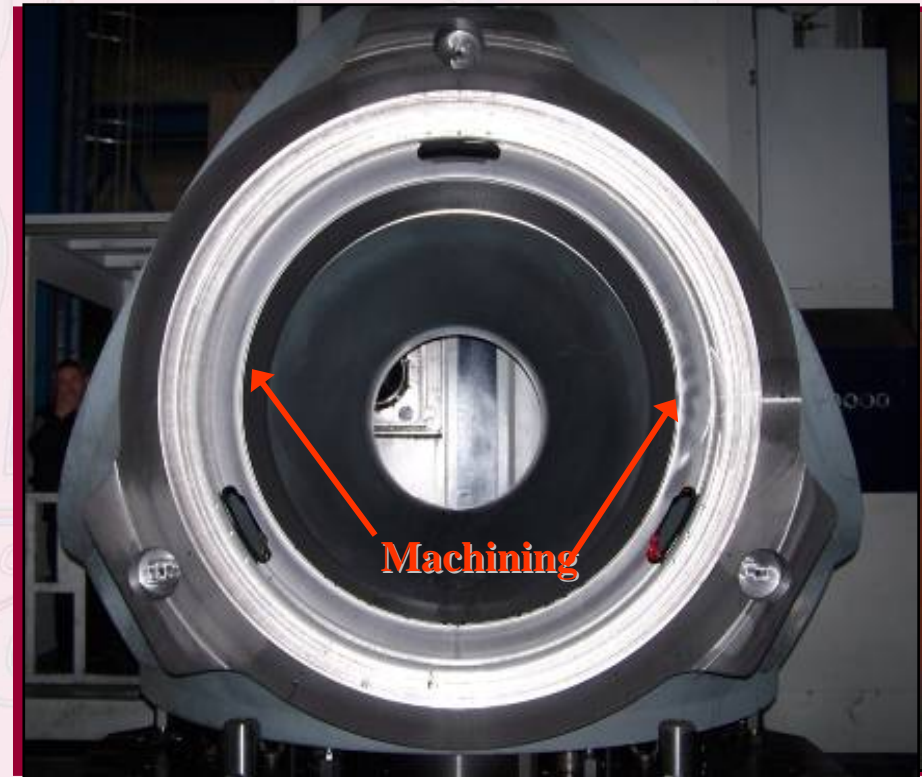


Mill Slotting

HELITANG Special Extended Flute Cutters
T490 LINE

Side Milling Application

One Assembly that can be used as two separate tools



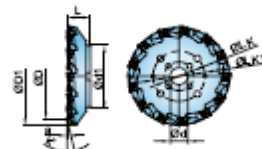
**Tangential Positive Insert with 4
Cutting Edges for 90° Shoulder!**

立装螺旋刃铣刀---S-MAX



S-MAX PLANFRÄSER SP2L_R

FÜR WECHSELKOPFSYSTEM



Artikel-Nr.	D	D1	d	d1	IK	LK1	L	α	a	Z	β	①
SP2L100000	100	138,5	32	90	-	-	50	13	3,5	5	1,4°	2,80
SP2L125000	125	163,5	40	100	-	-	63	13	3,5	6	1,35°	4,80
SP2L160000	160	198,3	40	130	66,7	-	63	13	3,5	7	1°	7,20
SP2L200000	200	238,3	60	160	101,6	-	63	13	3,5	9	0,9°	9,90
SP2L250000	250	288,3	60	221	101,6	177,8	63	13	3,5	11	0,4°	15,50

DPM43 GR105



DPM43 GR105/1



Artikel-Nr.	Ausführung	①	②	③	④	⑤	⑥
DPM43 GR105	positive Geometrie	●	●	●	●	●	●
DPM43 GR105/1	positive Geometrie, gefräst	●	●	●	●	●	●

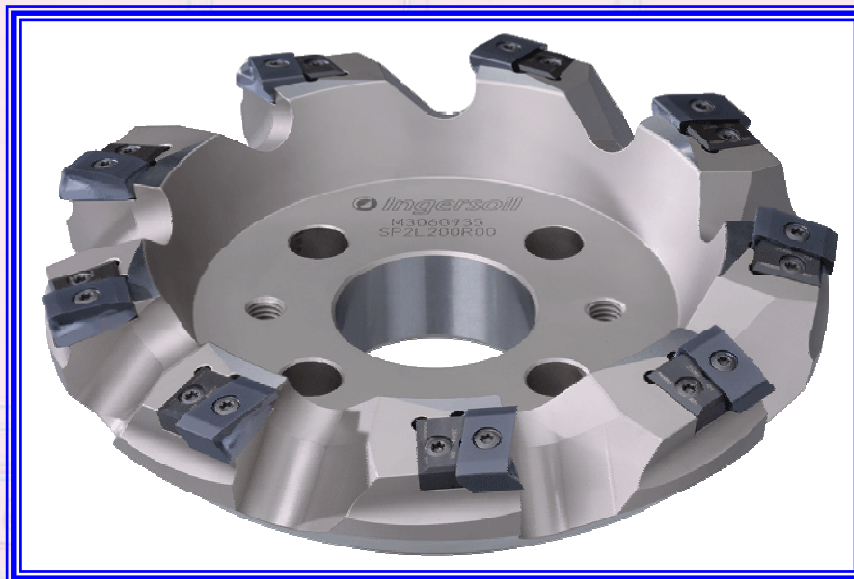
● = P ● = M ● = K ● = N ● = S ● = H

ZUBEHÖR



SM50-16x10 DG 200 PARW 20

① = Spannschraube ② = Schraubendreher ③ = Anlagelock





High feed-series

Werkzeug: SP2L250L11

Material: ST52

Vc=140 m/min

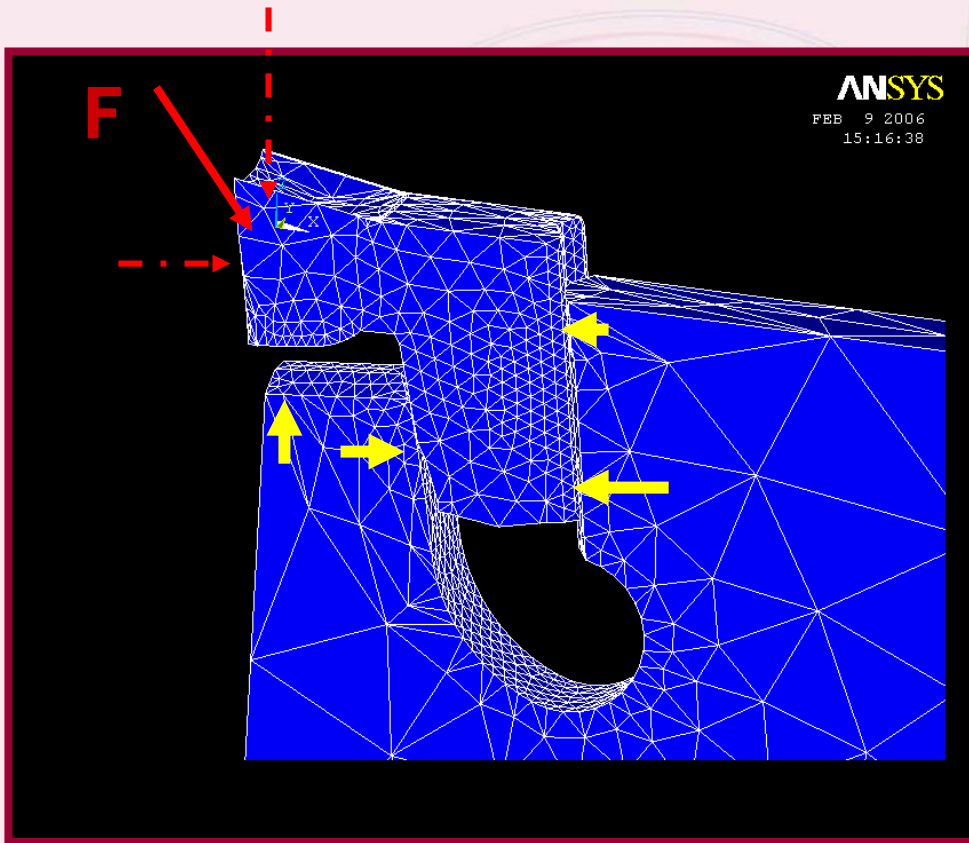
Vf=6500mm/min

Hochvorschub-Serie SP2L



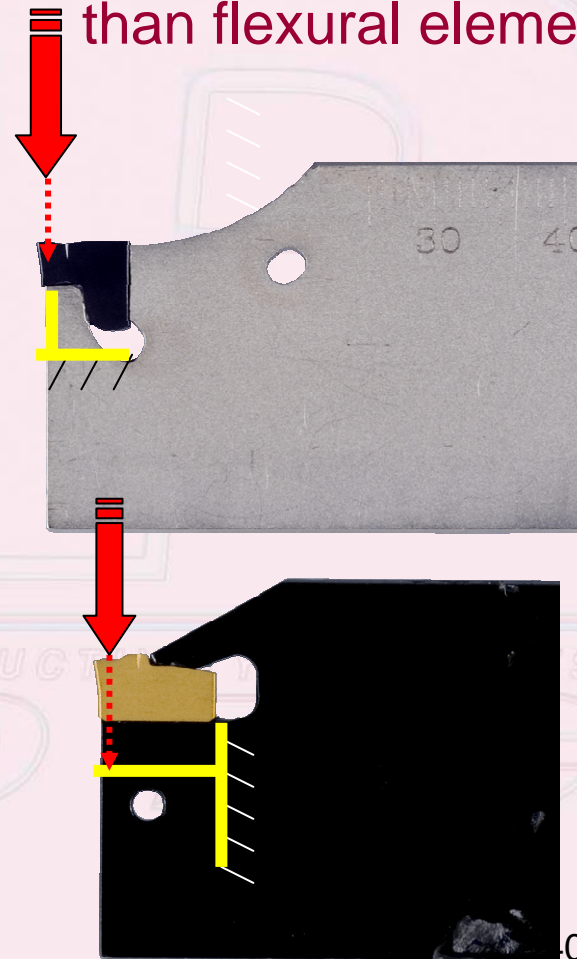


Technical Specifications: Force Analysis



An extra 40% gripping force

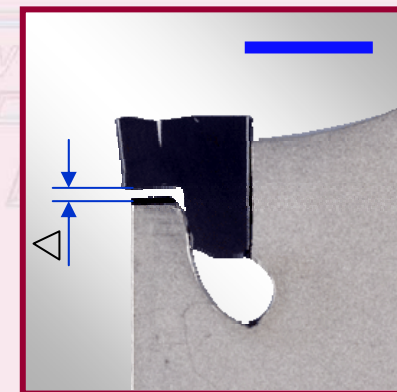
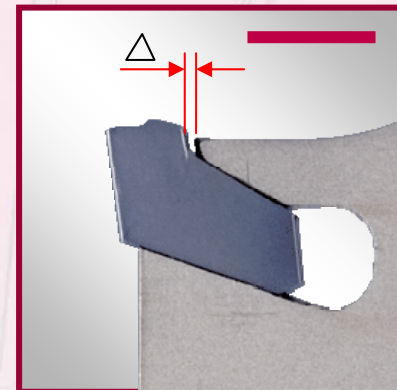
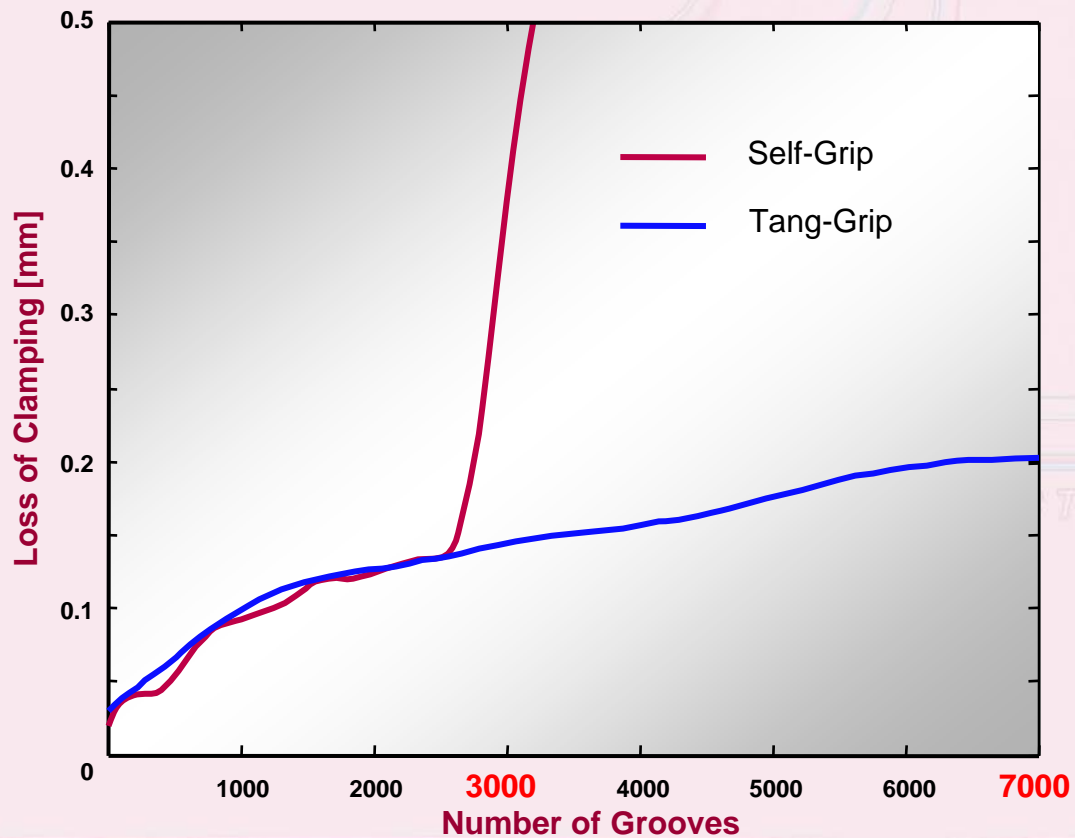
Bar elements are stiffer than flexural elements





Pocket Lifetime

- ❑ Machining Conditions
- ❑ Cutting Speed : 150 m/min(495sfm)
- ❑ Feed : 0.25 mm/rev (.0098ipr)
- ❑ a_p : 18 mm(.7")





车削_切槽

立装 螺钉夹持 - 应用于重型切削



立装 螺钉夹持 - 外圆车削 刀片刚性更佳
螺钉夹持 - 刀片车削更稳固



SUMO-GRIP
TANG GRIP HEAVY DUTY LINE

车削_切槽

立装 **螺钉夹持** - 应用于重型切削
来自德国的案例

SUMO-GRIP
TANG GRIP HEAVY DUTY LINE



Vc 切削速度 : 140 m/min

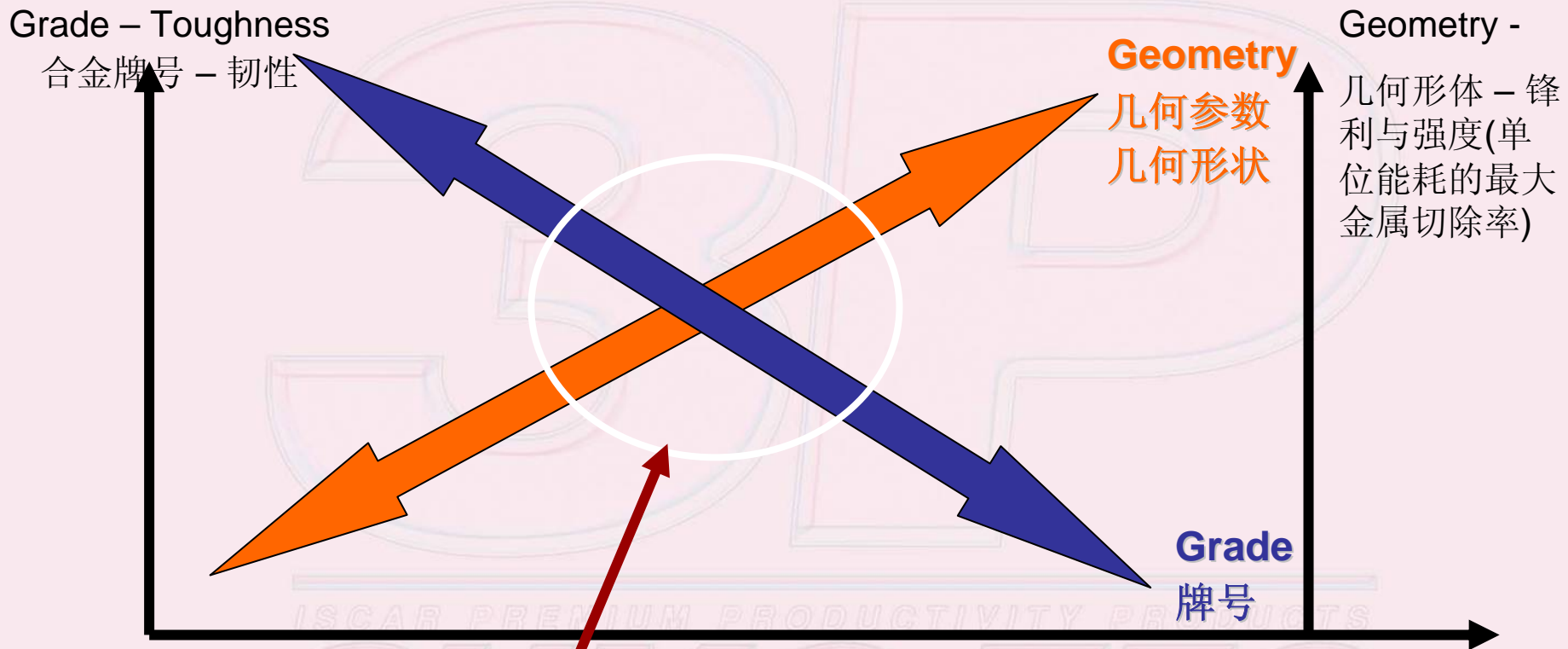
F 进给 : 0.7 mm/rev

a 切削深度 : 5 mm



大进给 断续车削 - 0.7mm/rev
在刚性上有重大区别, RCMT 刀片于1.5 分钟后失效⁴⁸

Requirements from Cutting Tool 对切削刀具的要求



**Optimum balance between
grade and geometry**

在合金牌号与几何形体间寻找最佳平衡点

THANK YOU

ISCAR PREMIUM PRODUCTIVITY PRODUCTS
SUMO TEC