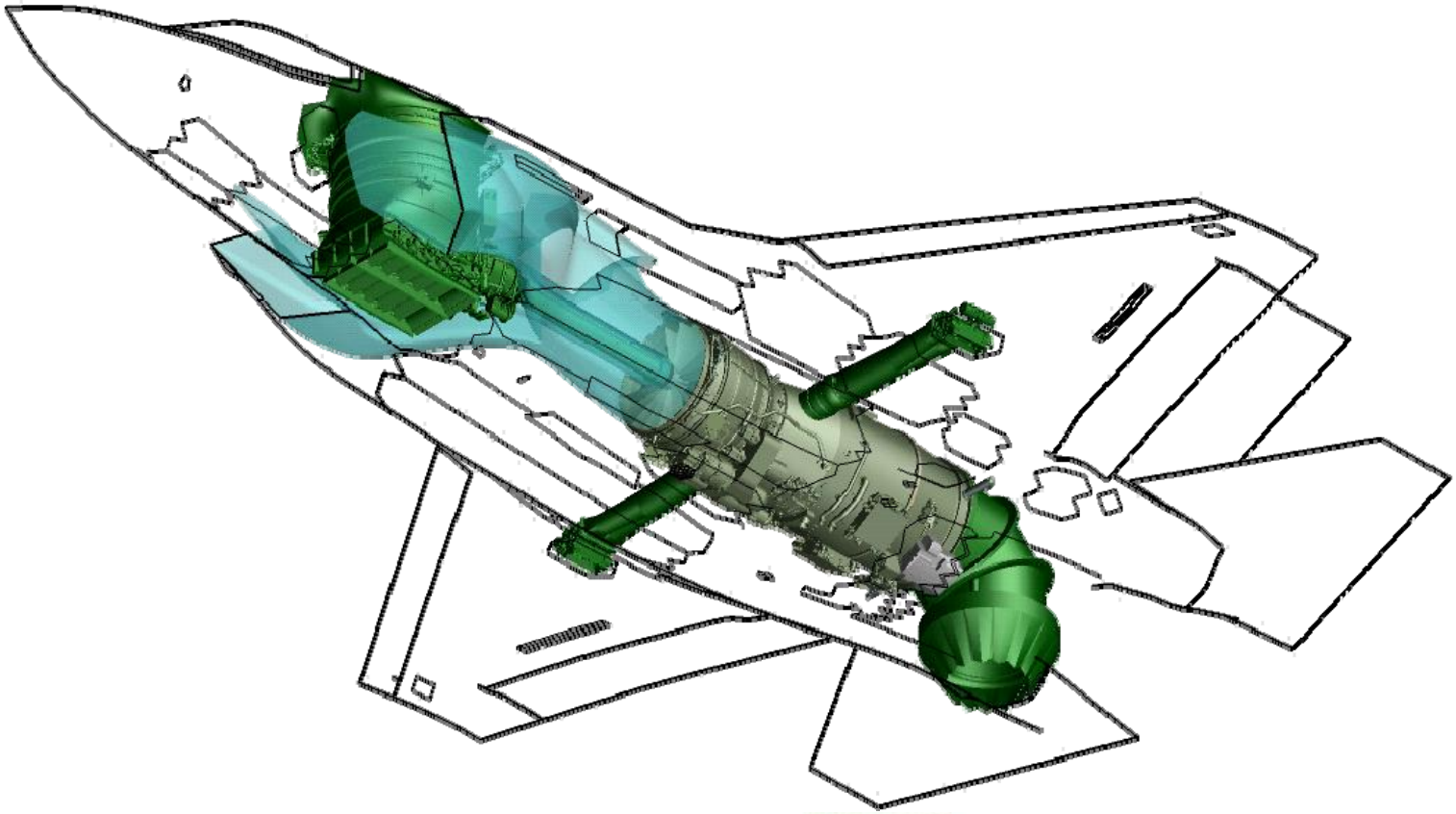
针对航空航天难加工材料的
山高Jetstream刀具和TS新材质

广东 深圳

2008 11 08

Jetstream 高压喷冷式刀具技术研制的背景介绍

JSF F135/6 Joint-Project Rolls-Royce & SECO



SECO

ROLLS ROYCE

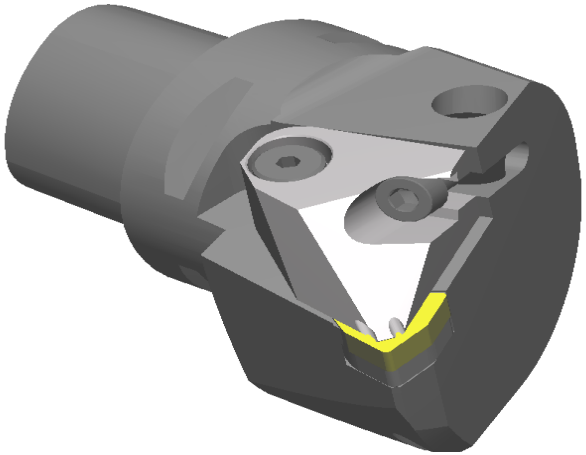
Rolls-Royce

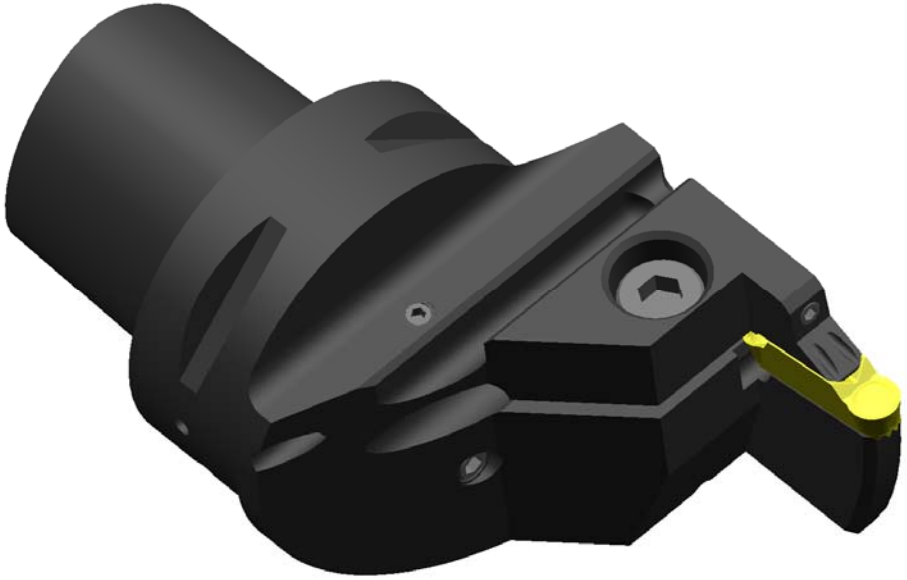
Jetstream 高压喷冷式刀具技术研制的背景介绍

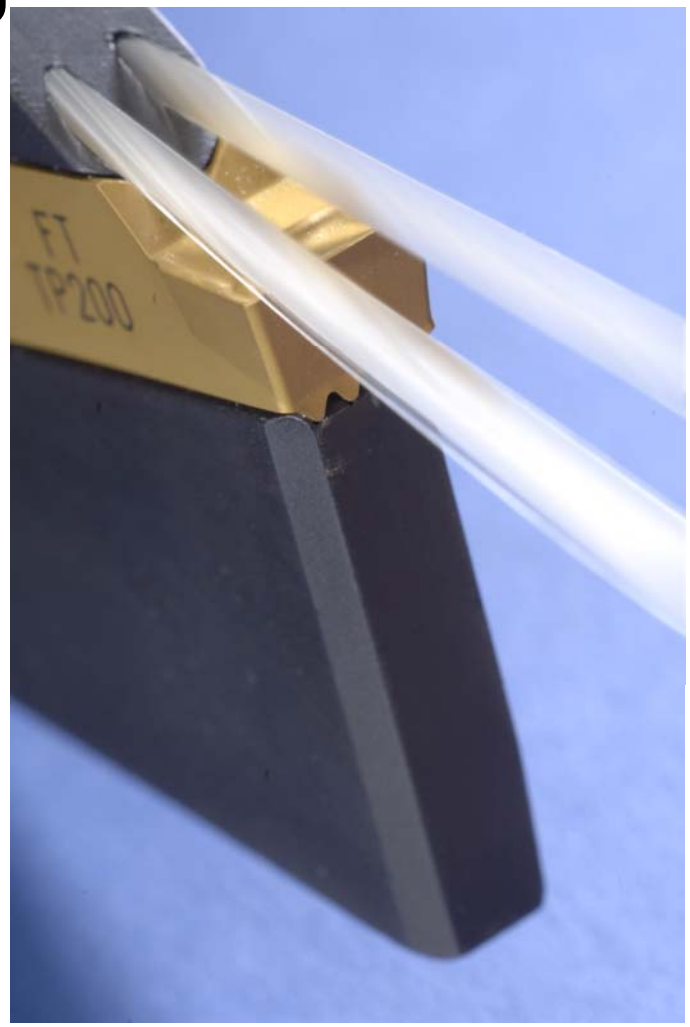
JSF F135/6 Joint-Project Rolls-Royce & SECO

非常糟糕的断屑及排屑状况严重影响加工的
效率和产品质量、安全、经济性

Seco Jetstream Tooling™







Seco Jetstream Tooling™

什么是 Seco Jetstream Tooling™?

- 它是一个高性能刀具系列，设计成冷却液直接传送到刀片的切削区。

- 能传递的冷却液压力范围：1 至 275 bar (15 – 3990 psi)。

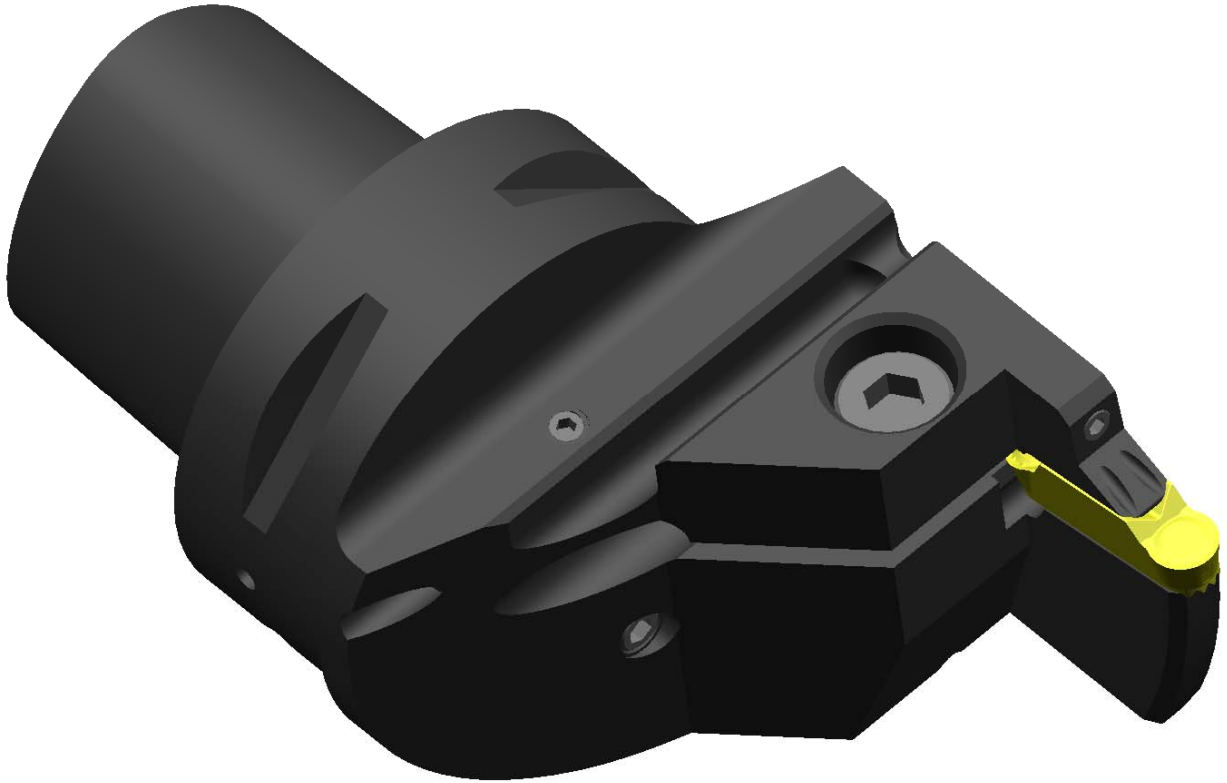
Seco Jetstream Tooling™

压力定义:

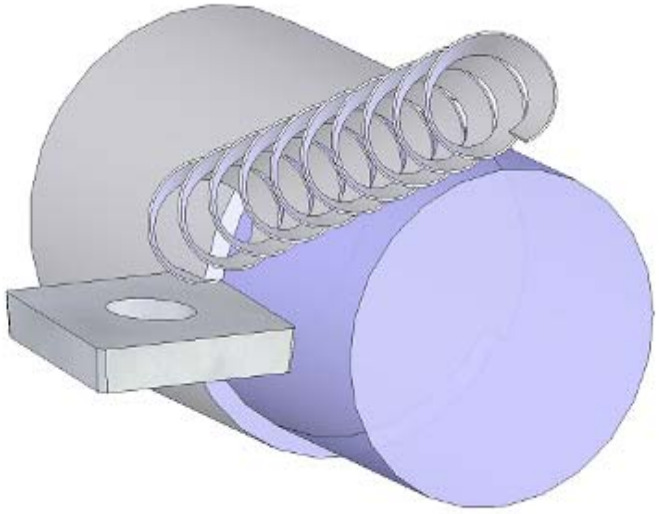
- 低压 (目前最常见) **< 20 bar (290 psi)**
- 高压 **= 20 – 70 bar (290 – 1015 psi)**
- 超高压（**UHP**） **> 70 bar (> 1015 psi)**

Seco Jetstream Tooling™

Seco Jetstream Tooling™ 是如何工作的?

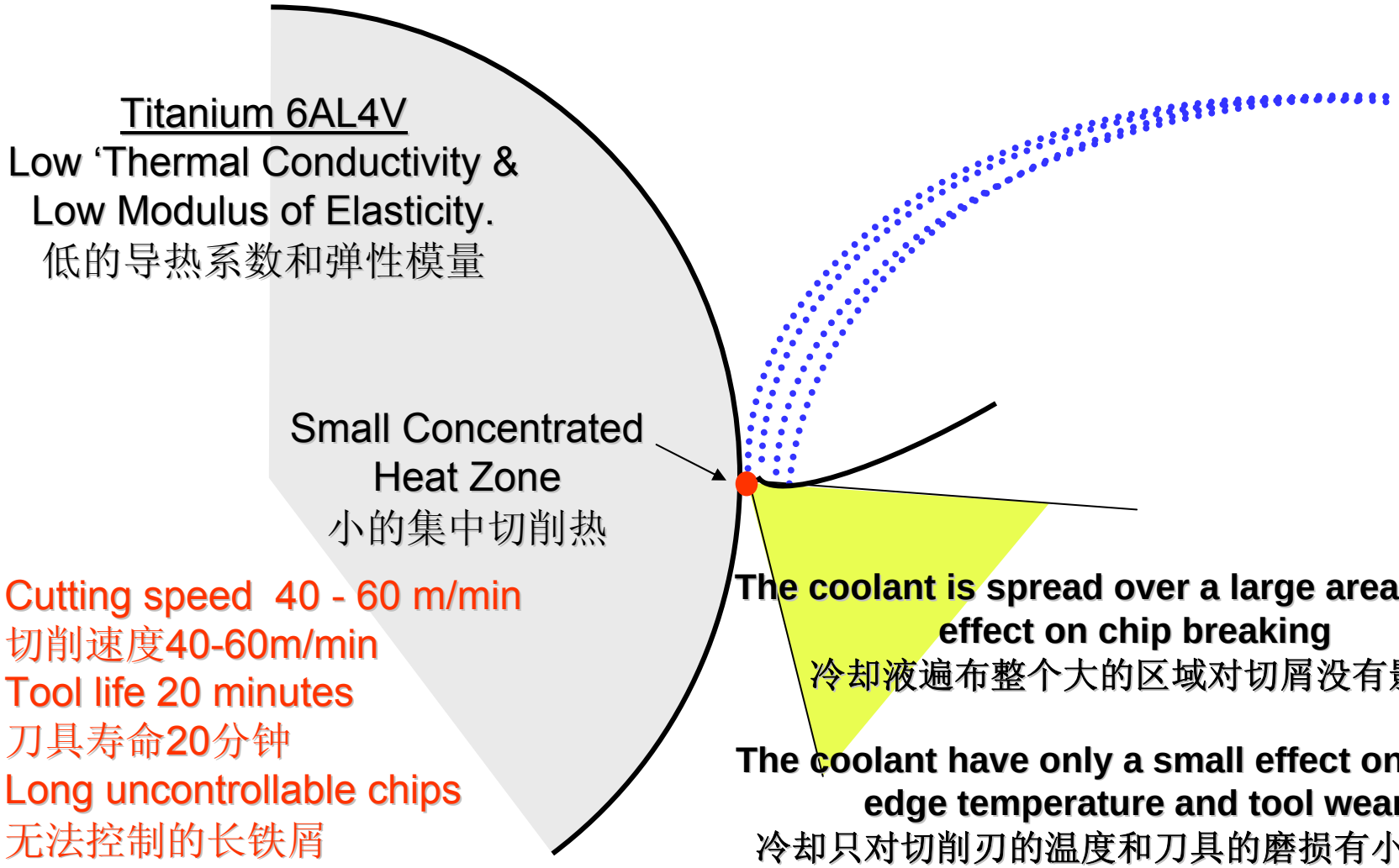


Conventional coolant supply
常规的冷却供给

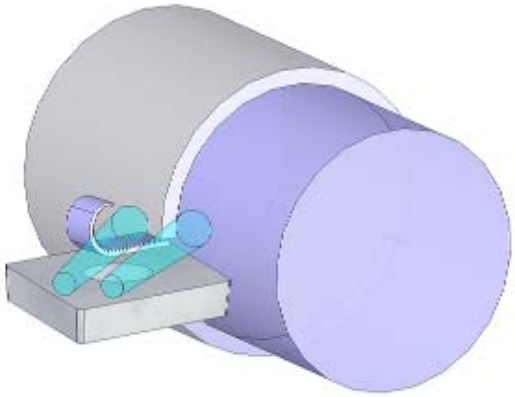


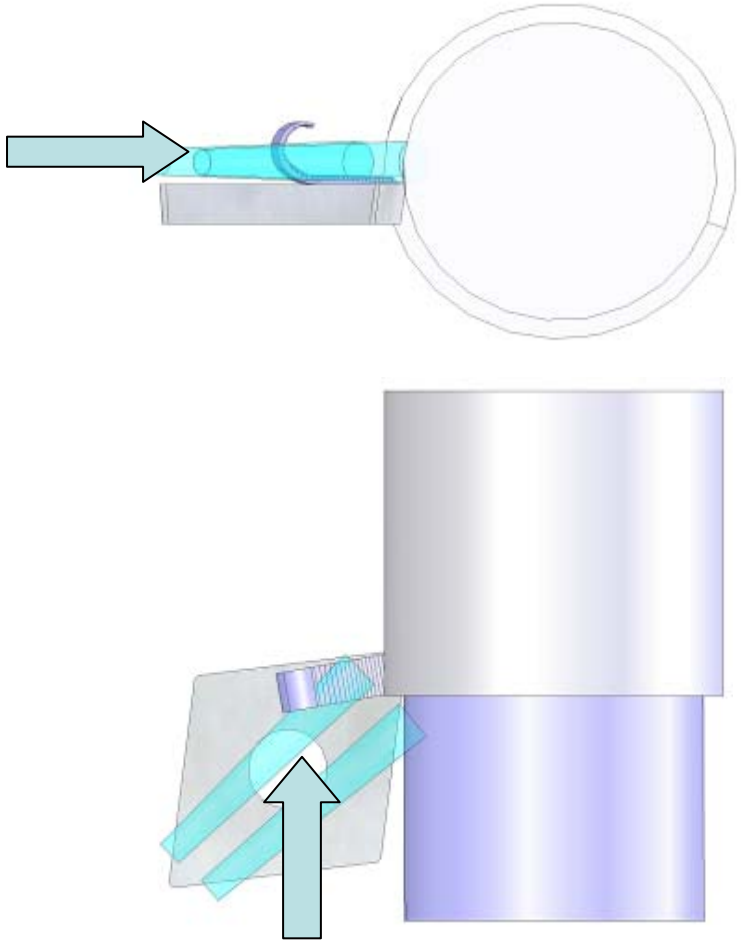
Conventional flood cooling produces long spiral chips

Conventional coolant supply
常规的冷却供给

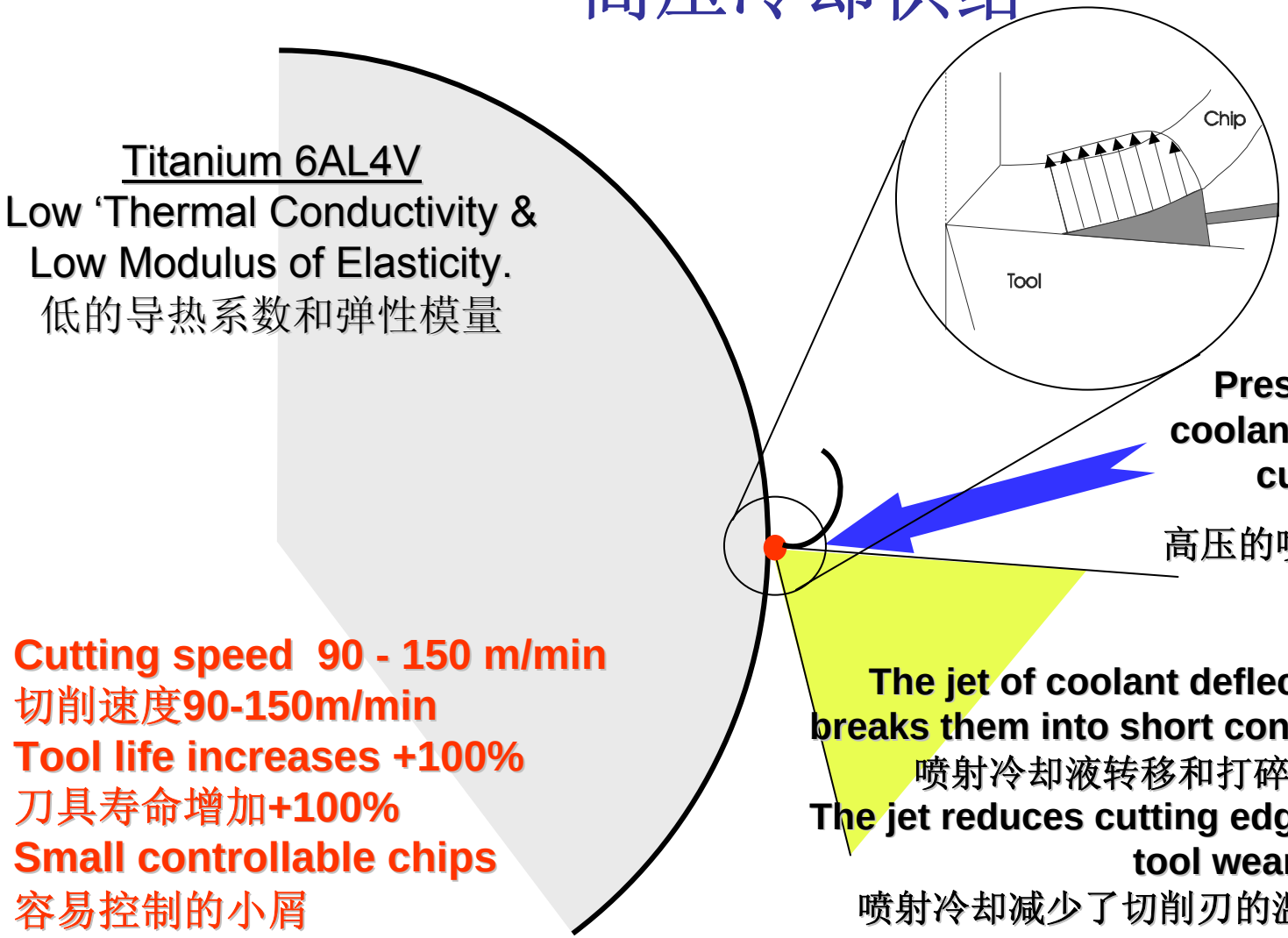


High pressure coolant supply
高压冷却供给





High pressure coolant supply
高压冷却供给



Titanium 6AL4V
Low 'Thermal Conductivity &
Low Modulus of Elasticity.
低的导热系数和弹性模量

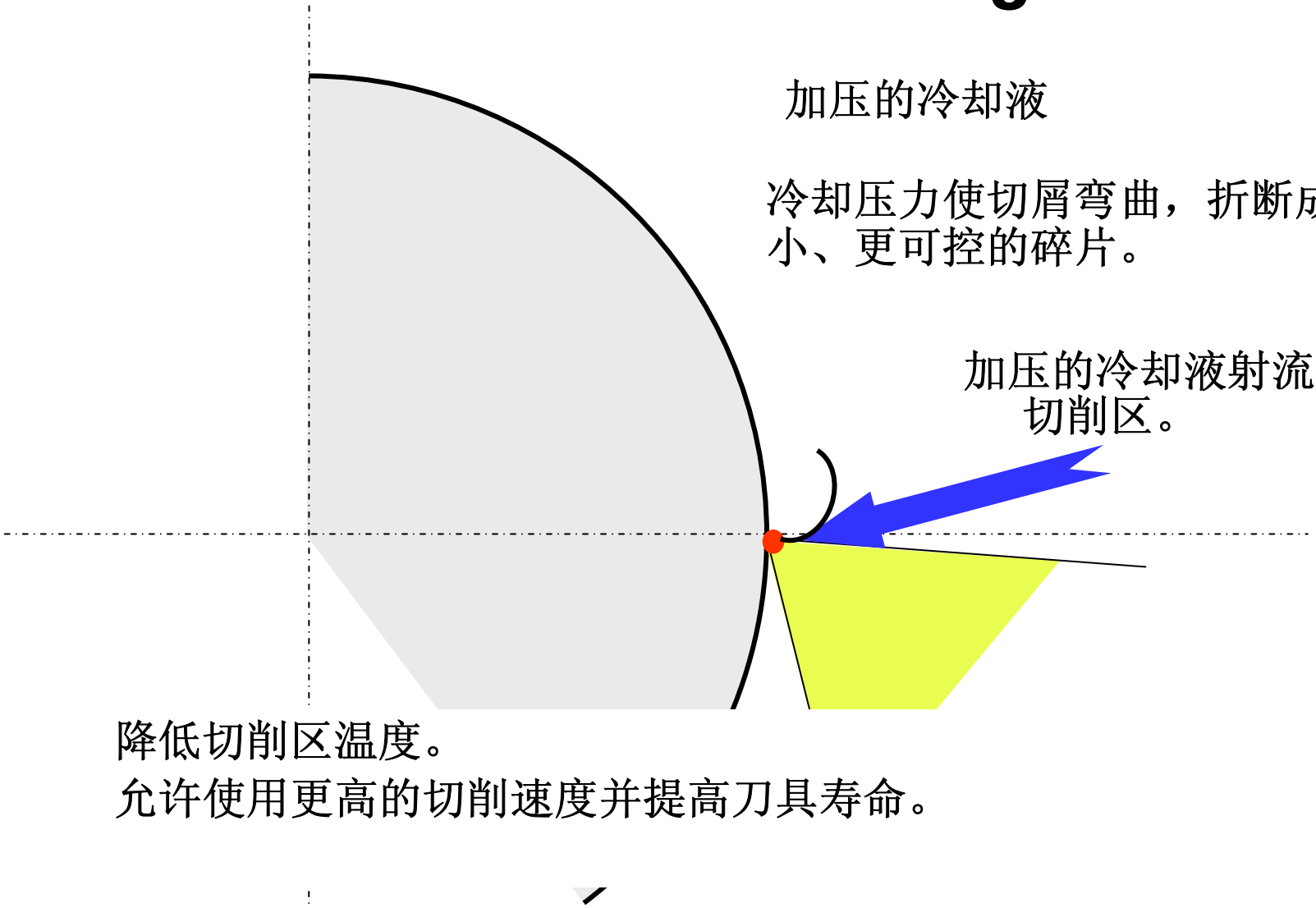
Pressurized jet of coolant directed at the cutting point

高压的喷射冷却液直接喷到切削点

Cutting speed 90 - 150 m/min
切削速度90-150m/min
Tool life increases +100%
刀具寿命增加+100%
Small controllable chips
容易控制的小屑

The jet of coolant deflect the chips and breaks them into short controllable segments
喷射冷却液转移和打碎它们成为碎屑
The jet reduces cutting edge temperature and tool wear
喷射冷却减少了切削刃的温度和刀具的磨损

Seco Jetstream Tooling™

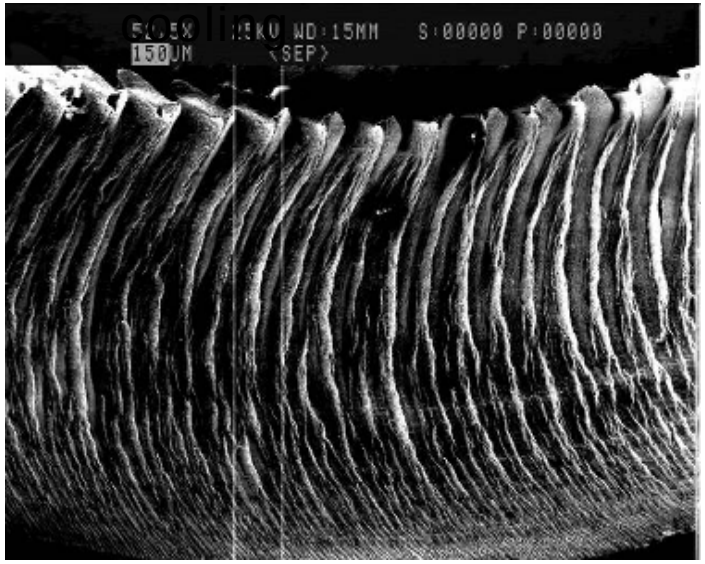


降低切削区温度。
允许使用更高的切削速度并提高刀具寿命。

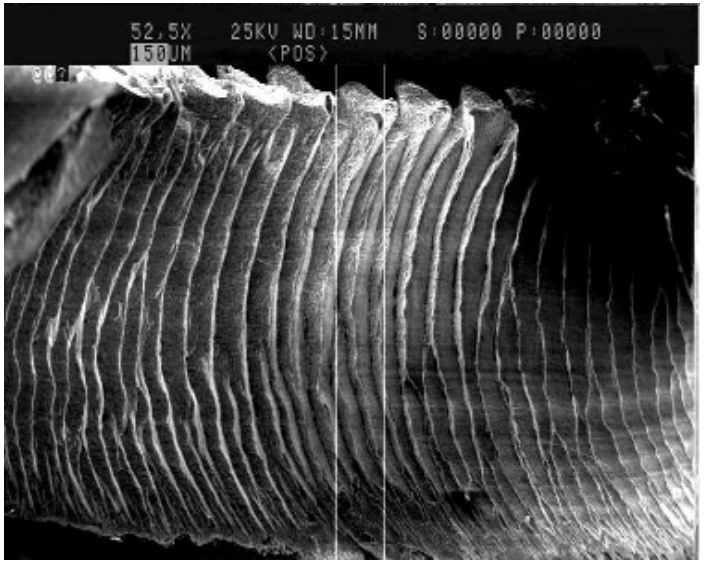
High pressure coolant supply
高压冷却供给

SEM Images Ti6-4: Topside

Conventional



Jetstream cooling



As a result Jetstream chips:

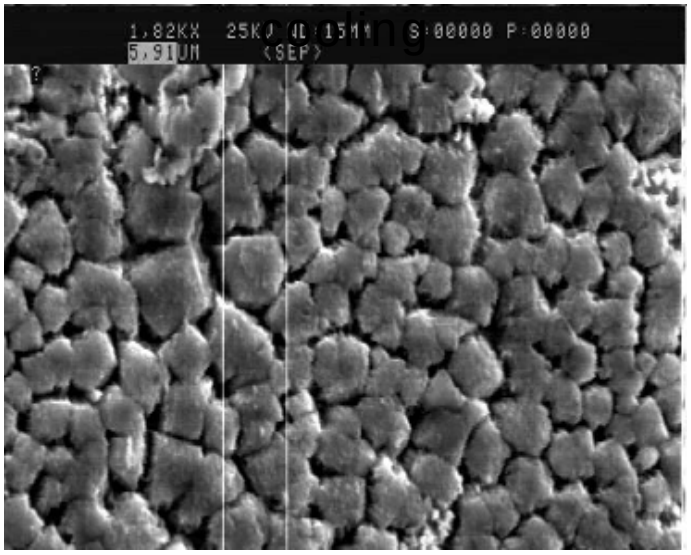
- **Have a tighter curl**
- **Are less likely to be helical**
- **Are more likely to hit the work piece (work piece acting as a chip breaker)**

Source: Dr Paul Dunkley, Warwick University

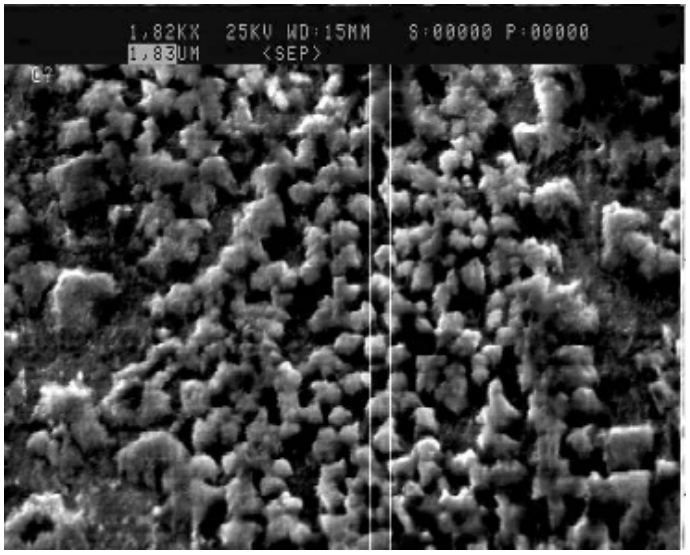
High pressure coolant supply
高压冷却供给

SEM Images Ti6-4: Tool chip interface

Conventional



Jetstream cooling

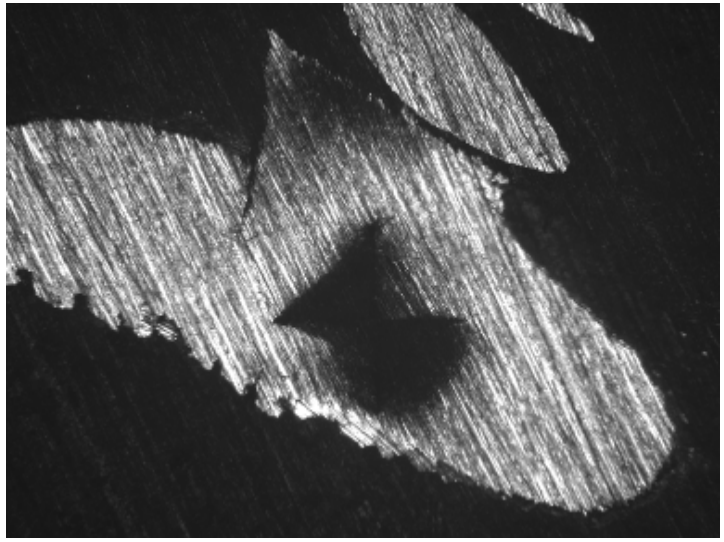


Smaller grain size means the chips are harder and more brittle
相对细小的晶粒意味着切屑具备更大的脆性而变得容易断屑

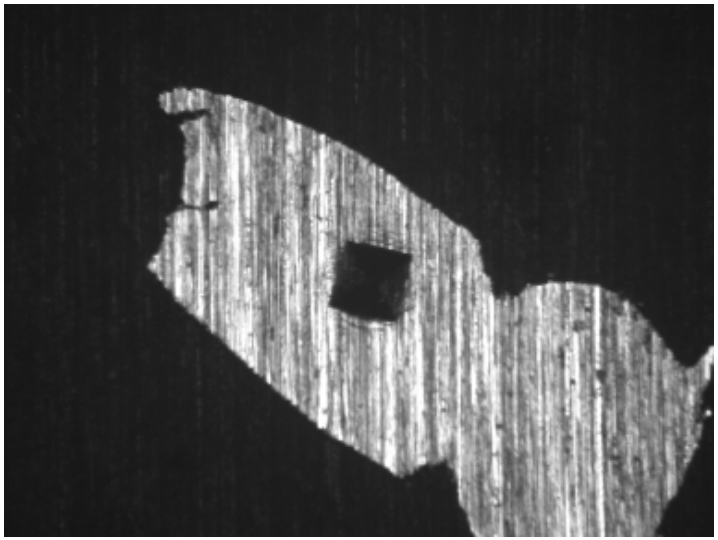
High pressure coolant supply
高压冷却供给

SEM Images : Vickers Hardness Test

Conventional cooling



Jetstream cooling



在对切屑进行压痕测试后显示，用Jetstream方式加工得到的断屑脆性更高

Source: Dr Paul Dunkley, Warwick University

Seco Jetstream Tooling™

应用:

- 能适用于大多数机床，不管是新机床还是经过改造 **(UHP**系统约增加机床价格**20%)**。
- 可连接大多数的工具系统。

- 通常从带有效冷却压力的现有机床开始。仅在第二步时，你或许需要讨论进一步的改进，需要更换更高压力的机床、泵等。

Seco Jetstream Tooling™

要求 (检查清单):

在高压时考虑:

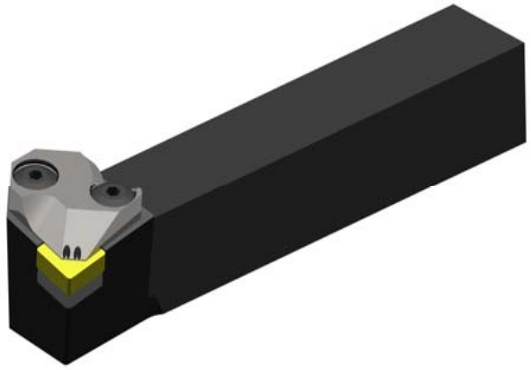
- 机床的密封。
- 排气/通风。
- 冷却液的过滤 (冷却液内的颗粒可能对工件表面产生“喷砂”作用。
- 增加冷却液的消耗 (+10%)。
- 更大的泵意味着更高的容积 -> 更大的冷却液储存箱。
- 高压冷却液束可能使薄壁零件变形。
- 高压冷却液束可能对手和手指产生危害。
- 压力越高，系统更复杂。

注意：这是一个需要对客户谈及的检查清单。每个应用都有其个性。我们有责任谈及这些话题，而客户必须找到答案。

Seco Jetstream Tooling™ – 描述

杆式刀具

- 普通产品描述，如 PCLNR2525M12
- 增加 JET
- PCLNR2525M12JET



Seco-Capto 刀具

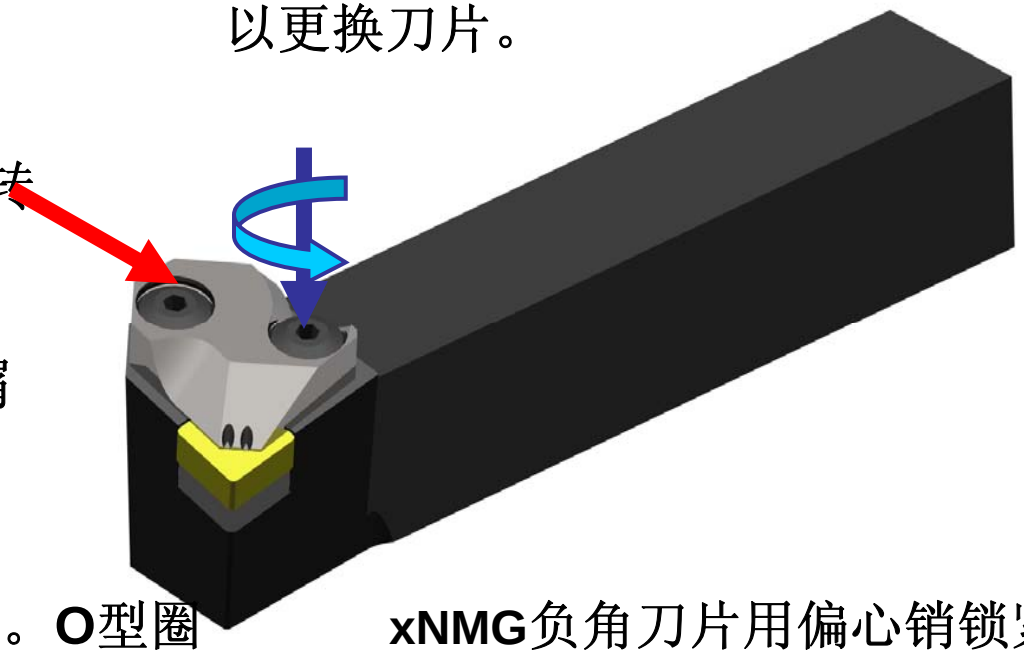
- 普通产品描述，如 C6-PCLNR-45065-12
- 增加 JET
- C6-PCLNR-45065-12JET

Seco Jetstream Tooling™ – 设计

旋转式冷却液引导器
(专利待批)

旋松螺钉并转开引导器
以更换刀片。

引导器绕该螺钉旋转



引导器被塑造成有利于切屑
的流出

冷却液从引导器下方进入。O型圈
置于分离点的槽内。

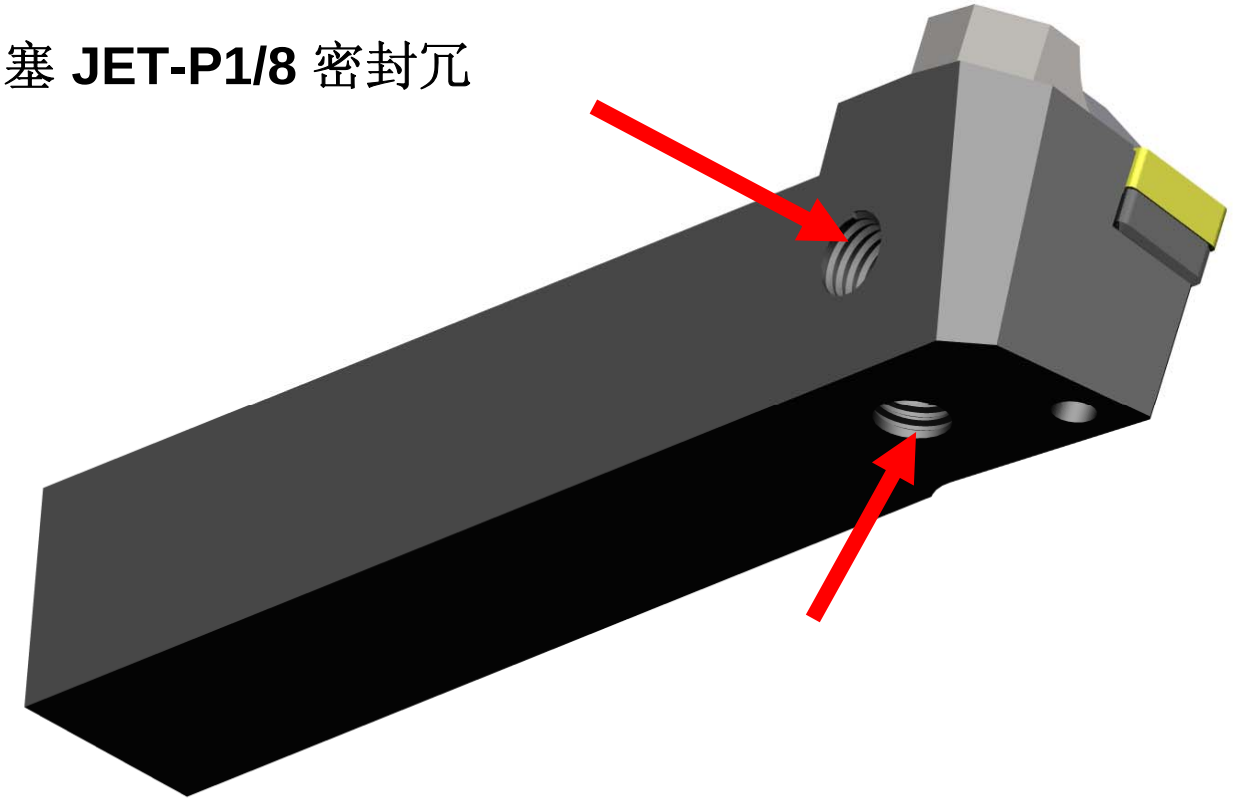
xNMG负角刀片用偏心销锁紧

xCMT 正角刀片用中心螺钉锁紧

Seco Jetstream Tooling™ – 设计

冷却液入口:

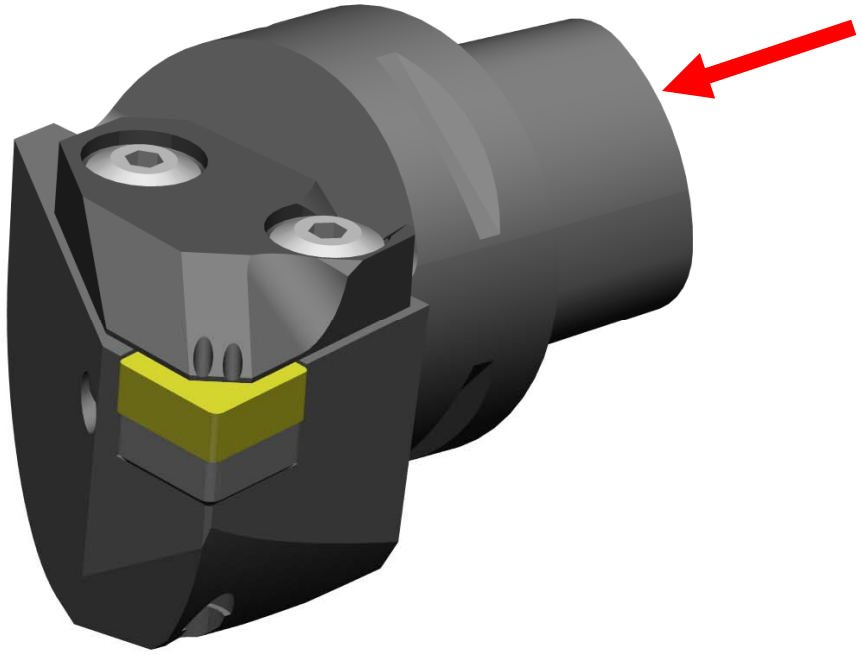
有两种位置供选择。闷塞 **JET-P1/8** 密封冗余的入口位置。



Seco Jetstream Tooling™ – 设计

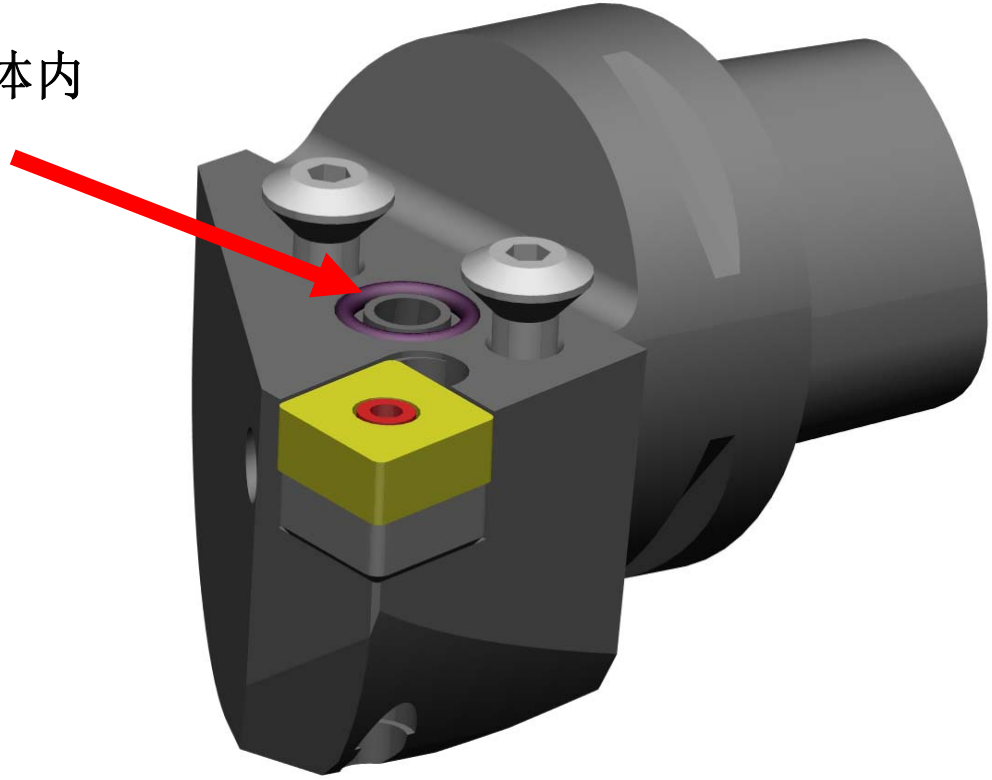
旋转式冷却液引导器
(专利待批)

与杆式刀具的所有设计特性相同，除了冷却液从刀具的后方（内冷通路）进入外。

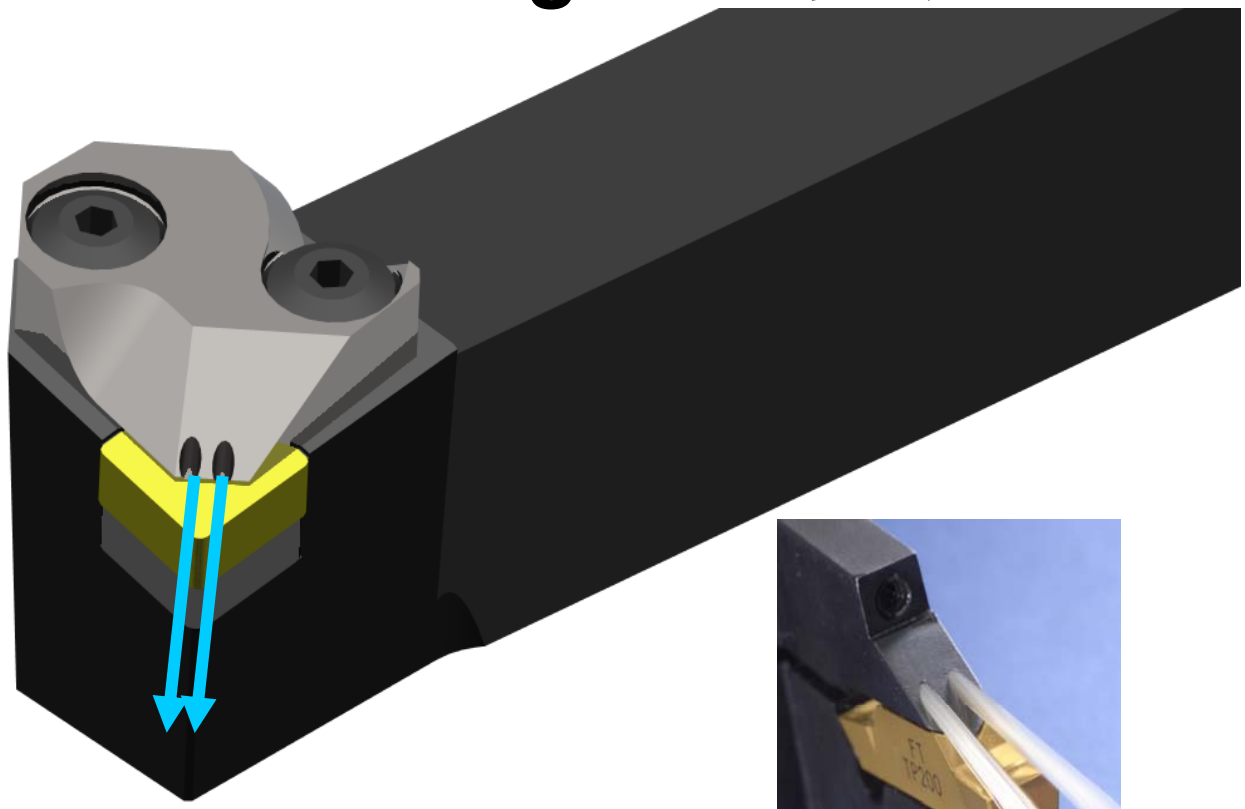


Seco Jetstream Tooling™ – 设计

‘O型圈’ 被水平地放置在刀体内



Seco Jetstream Tooling™ – 设计



冷却液束直对切削的方向

Seco Jetstream Tooling™ – 好处

好处:

- 提高切削参数
  - = 提高生产率
- 增加刀具寿命
  - = 降低成本
  - = 减少为刀片转位而设的程序中断
- 改善切屑控制
  - = 减少由操作工干预引起的停机时间
- 改善表面粗糙度

Seco Jetstream Tooling™ – 好处

应用领域:

钛合金 Ti6Al-4V (典型价值所在)

- 切削速度 +50%
- 加工节拍缩短 –50 %
- 刀片消耗 – 60 %
- 极佳的切屑控制, 更少的停顿 (见照片)
- 有效的冷却液传送
- 改善表面粗糙度

传统冷却

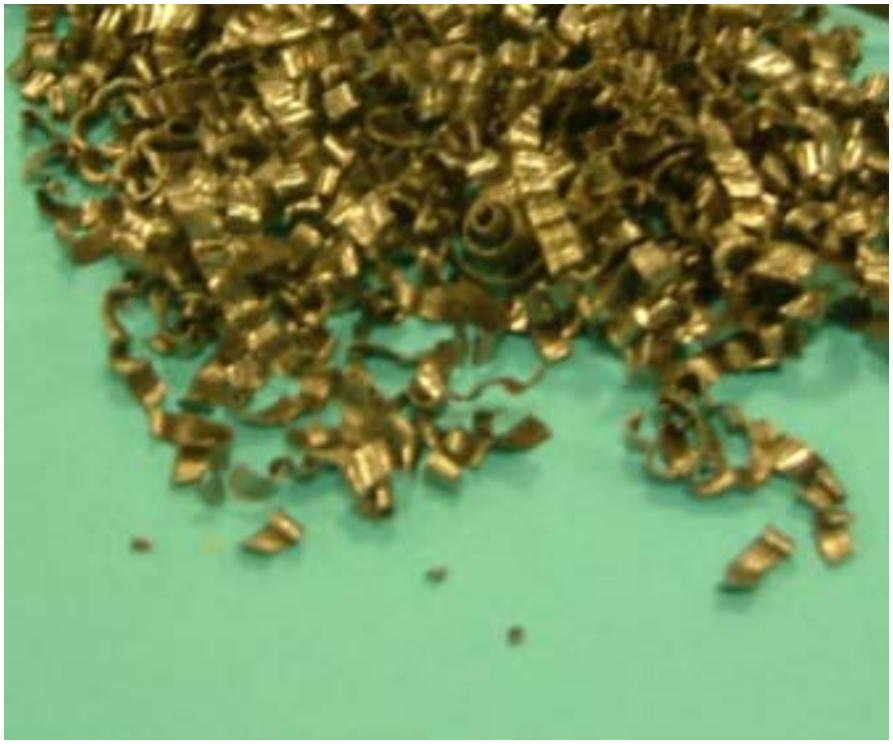
Jetstream Tooling™

Seco Jetstream Tooling™ – 好处

低压和高压时生成的切屑比较

钛合金 **Ti6Al4V**

传统刀具
冷却液供应压力低



Jetstream Tooling™
冷却液供应压力高

Seco Jetstream Tooling™

- 钛合金 Ti6Al-4V

  主要应用领域

- Nimonic C263, INCO 718
- 铝合金
- 不锈钢、合金钢

与大学的合作

车削项目:

- 用各种刀具材料和不同的加工工况下，高速加工 Ti 6Al-4V 和 Inconel 718 。

- 进给量 f = 0.15mm
- 切削深度 a_p = 0.5mm
- 冷却液浓度 6%
- 冷却液供应: 70bar, 110bar, 203bar 冷却压力, 传统的冷却剂。

刀具类型:

- 未镀层硬质合金刀片: Seco - CNMG120412-M1, 883
- 镀层刀片: CNMG120412-M1, CP250
- 切削速度 v_c = 100, 110, 120, 130 和 150m/min

刀具失效标准:

	VB	VBmax	VNotch	(SR-Ra)
精加工 (mm):	0.3	0.4	0.6	1.6µm

结论 Ti 6Al-4V

- 1. 当用未镀层硬质合金刀具在相比传统冷却的70 、 110和203 bar高压下加工时，刀具寿命提高。
- 2. 沟槽磨损和后刀面磨损是用被调查刀具加工Ti 6Al-4V合金的主要磨损形式。
- 3. 用未镀层和镀层硬质合金刀具加工时生成的表面普遍能被接受，调查的所有工况均未出现开裂、折痕或裂纹等物理损坏。
- 4. 在被调查的用硬质合金精加工的切削工况中，已加工表面上没有观察到塑性变形。
- 5. 用山高CNMG120412-M1,883在70 bar冷却压力下进行精加工时，已加工表面没有发生明显的硬度变动。

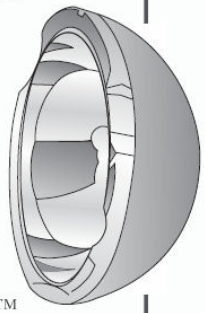
结论 Inconel 718

- 1. 在用硬质合金刀具加工时，冷却液压力从110 bar提高到203 bar ，刀具寿命的提高不明显。
- 2. 表面硬度依赖于施加的加工参数和冷却供应压力。
- 3. 通常，表面硬度 (距已加工表面 0.3mm 及以上深度处) 等同于Inconel 718的宏观硬度。
- 4. 在被调查的工况中，没有观察到已加工表面下的金相结构缺陷。
- 5. 在所有被调查的加工工况中， Inconel 718加工后没有发生相变，并因此不存在再次结晶。
- 6. 在所有调查的工况中，用硬质合金刀具精加工时获得刀具寿命显著提高的最优冷却压力为110 bar 。

Seco Jetstream Tooling™ – 应用

MACHINING EXAMPLE IN COBALT CHROME

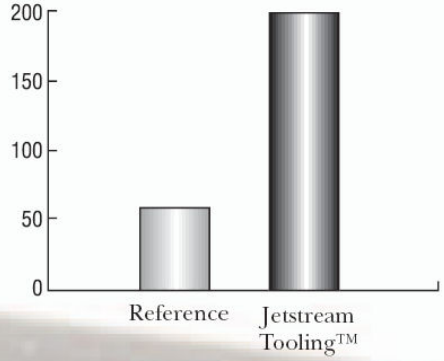
270% INCREASE IN TOOL LIFE



Component:	Cap	
Operation:	External Profile	
Material:	Cobalt Chrome	
Insert:	LCMF160500-0476-MP, 890	
	Reference	Jetstream Tooling™
Cutting Data:	v_c = 110 m/min (360 sfm)	v_c = 110 m/min (360 sfm)
	f = 0.1 mm/rev (.004 inch)	f = 0.1 mm/rev (.004 inch)
	a_p = 0.25 mm (0.01 inch)	a_p = 0.25 mm (0.01 inch)

Result: Improved chip control and tool life.

Components per insert



20 BAR
290 PSI

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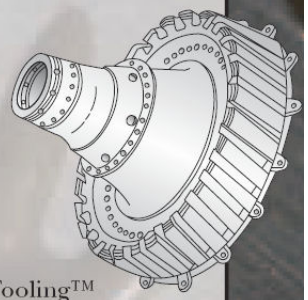
SUPER ALLOYS

MACHINING EXAMPLE IN TITANIUM

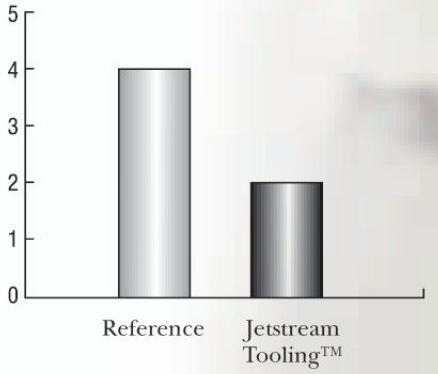
128% INCREASE IN CUTTING DATA



Component:	Hub	
Operation:	Internal roughing	
Material:	Ti6Al4V	
Insert:	SNMG190612-MR4, 883	
	Reference	Jetstream Tooling™
Cutting Data:	v_c = 35 m/min (115 sfm)	v_c = 80 m/min (262 sfm)
	f = 0.35 mm/rev (.014 inch)	f = 0.35 mm/rev (.014 inch)
	a_p = 8.0 mm (.32 inch)	a_p = 8.0 mm (.32 inch)

Result: Flank and notch wear reduced, improved chip control.

50% reduction in Cycle time (minutes)



80 BAR
1160 PSI

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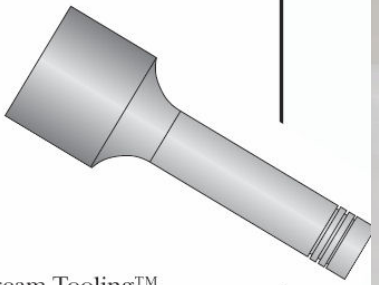
SUPER ALLOYS

Seco Jetstream Tooling™ – 应用

MACHINING EXAMPLE IN INCONEL 718

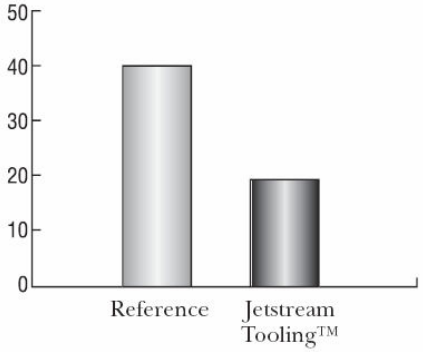
60% REDUCTION IN CYCLE TIME



Component:	Stem	
Operation:	Rough Turn	
Material:	Inconel 718	
Insert:	CNMG120408-MR4, CP250	
	Reference	Jetstream Tooling™
Cutting Data:	v_c = 30 m/min (98 sfm)	v_c = 90 m/min (295 sfm)
	f = 0.2 mm/rev (.007 inch)	f = 0.25 mm/rev (.01 inch)
	a_p = 1.0 mm (.04 inch)	a_p = 2.5 mm (0.1 inch)

Result: Improved chip control

Cycle time (minutes)



15 BAR
218 PSI

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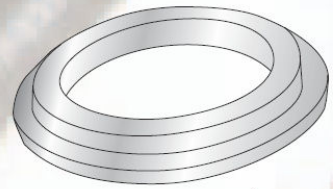
SUPER ALLOYS

MACHINING EXAMPLE IN JETHETE

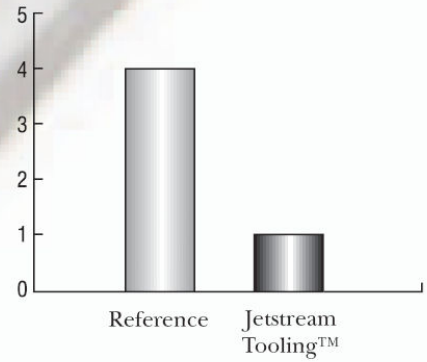
75% REDUCTION IN INSERT WEAR AND 40% IMPROVEMENT IN PRODUCTIVITY



Component:	Ring	
Operation:	Rough Turn	
Material:	Jethete (SMG9)	
Insert:	CNMG120412-M5, TP2500	
	Reference	Jetstream Tooling™
Cutting Data:	v_c = 130 m/min (426 sfm)	v_c = 160 m/min (525 sfm)
	f = 0.35 mm/rev (.014 inch)	f = 0.4 mm/rev (.016 inch)
	a_p = 5.0 mm (.2 inch)	a_p = 5.0 mm (.2 inch)

Result: Improved chip control with long strings reduced to short chips.

Insert edges per component

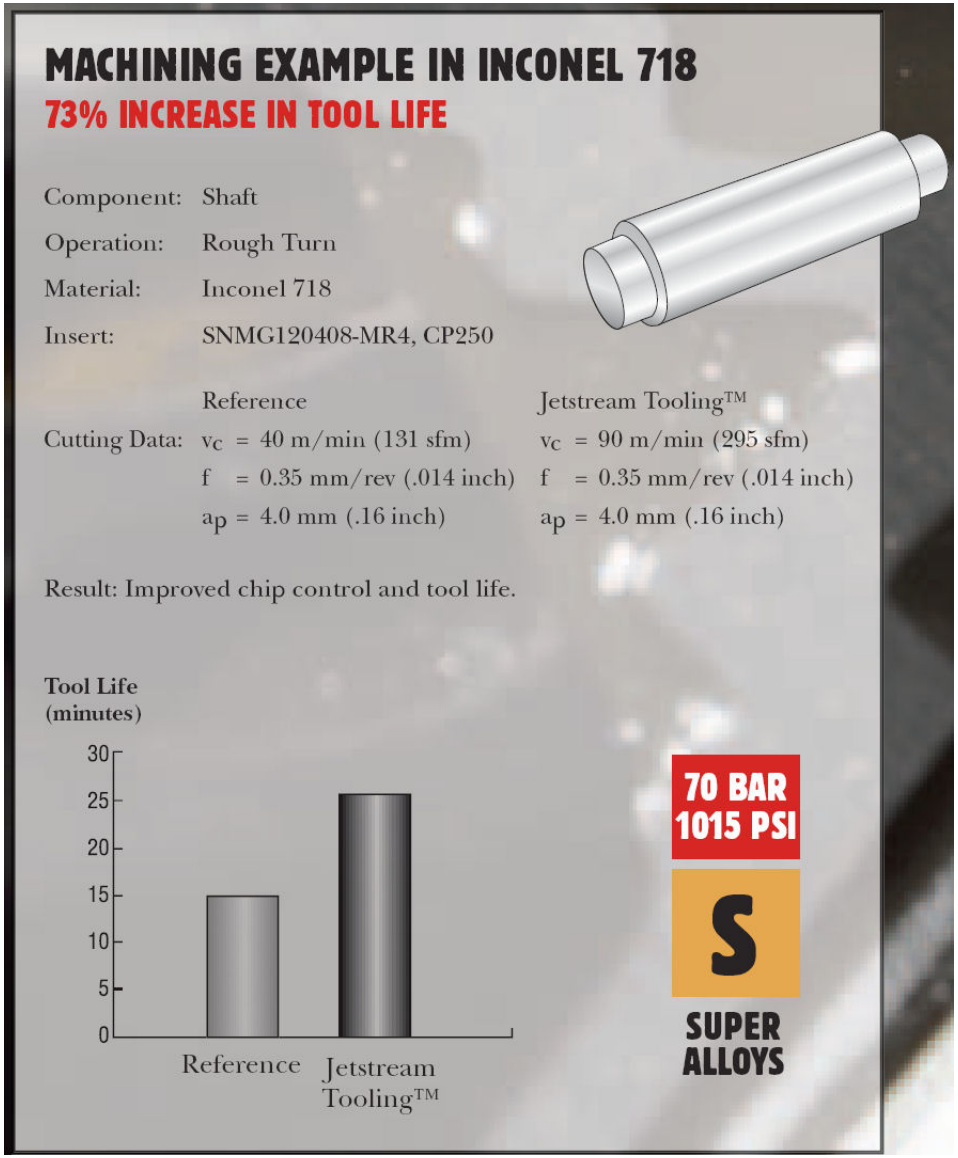


20 BAR
290 PSI

M

STAINLESS STEEL

Seco Jetstream Tooling™ – 应用



客户经验

客户经验 – 定向的冷却

- SNMG190612
- 材料 Ti 6Al-4V
- v_c = 80m/min
- f = 0,35mm
- a_p = 8mm
- T_e = 8.5min
- 冷却液出口 4 x Ø1,8mm
- 压力 80bar

使用带引导器（= 压力和方向）的刀杆生成的切屑

客户经验 – 定向的冷却

- **SNMG190612**
- 材料 **Ti 6Al-4V**
- **v_c = 80m/min**
- **ap = 8mm**
- **f = 0,35mm**
- **T_e = 2min**

- 传统的**Ø4mm** 冷却出口
- 压力 **80bar**

使用不带引导器（= 压力）的刀杆
生成的切屑

客户经验 – 涡轮盘车削

客户经验 –涡轮盘车削

客户经验 –涡轮盘车削

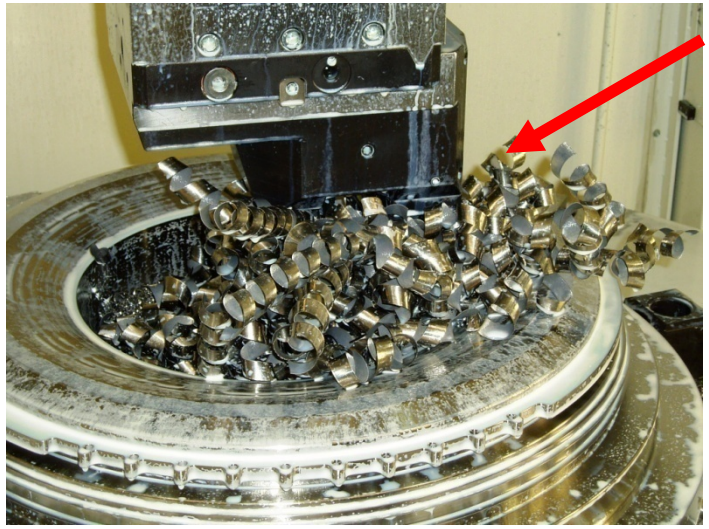
定向的高压冷却
Jetstream Tooling™

客户经验 –涡轮盘车削

- 加工节拍缩短 **50% +**
- 硬质合金消耗 **-60% +**
- 有效的冷却液传送 **+++**
- 切屑控制 **+++**
- 改善表面粗糙度

传统

Jetstream Tooling™

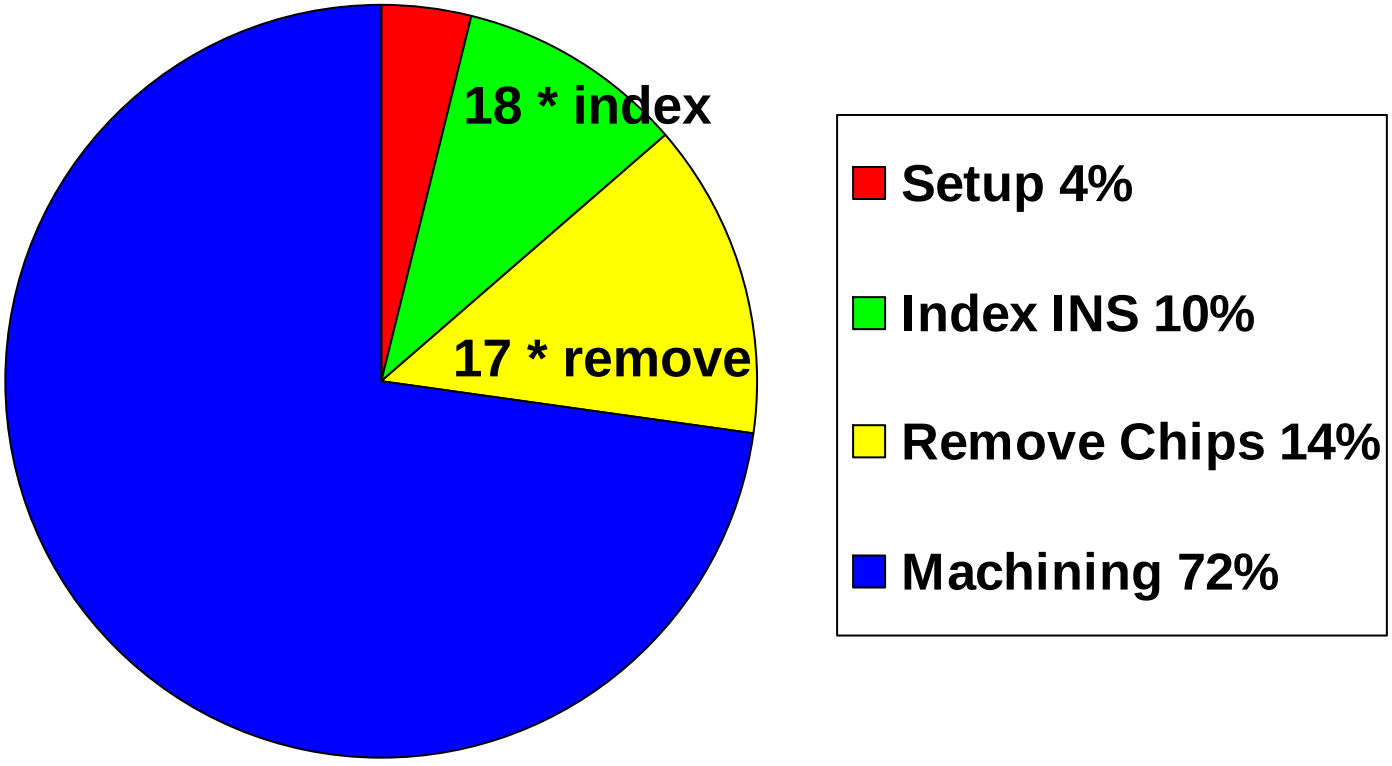


- 传统
- **Jetstream Tooling™**

Ti 6Al-4V

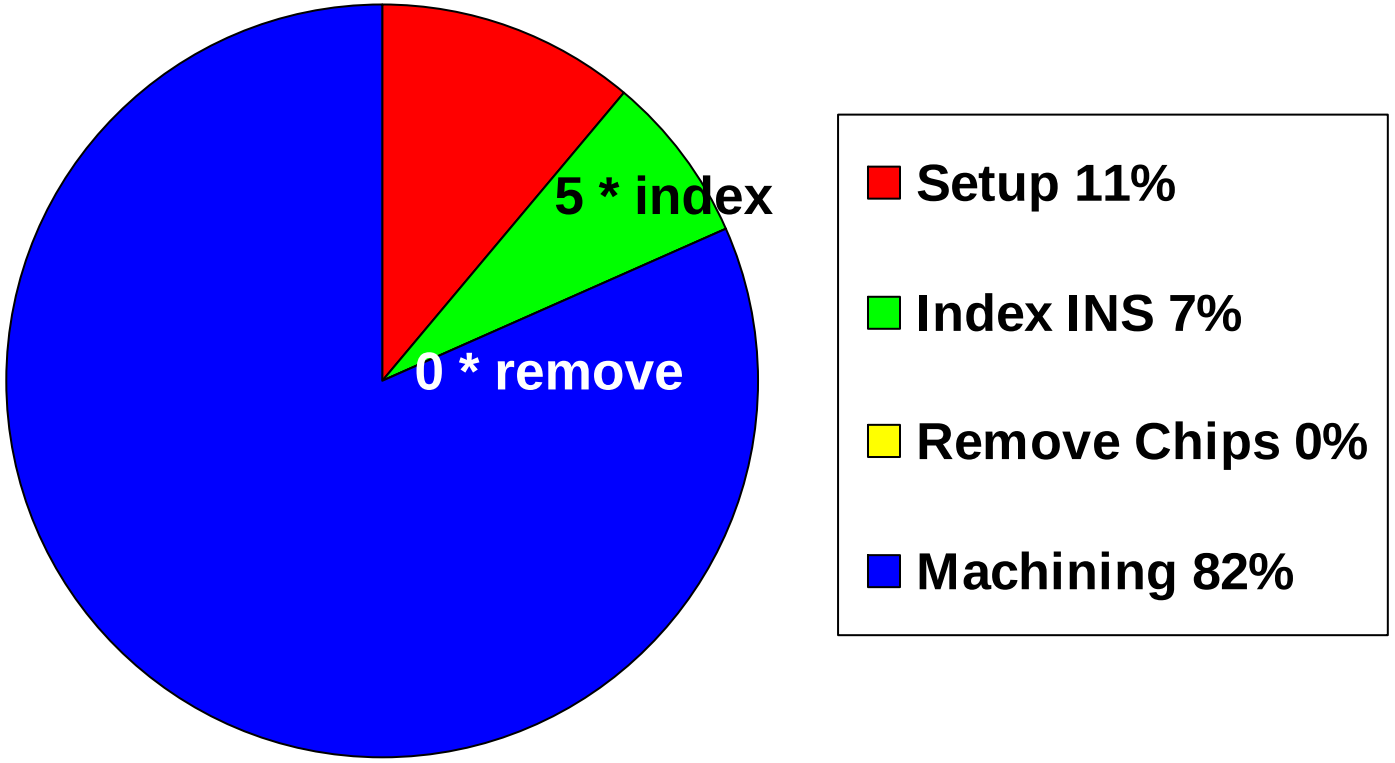
客户经验 –涡轮盘车削

- 涡轮盘加工的加工总节拍　传统冷却

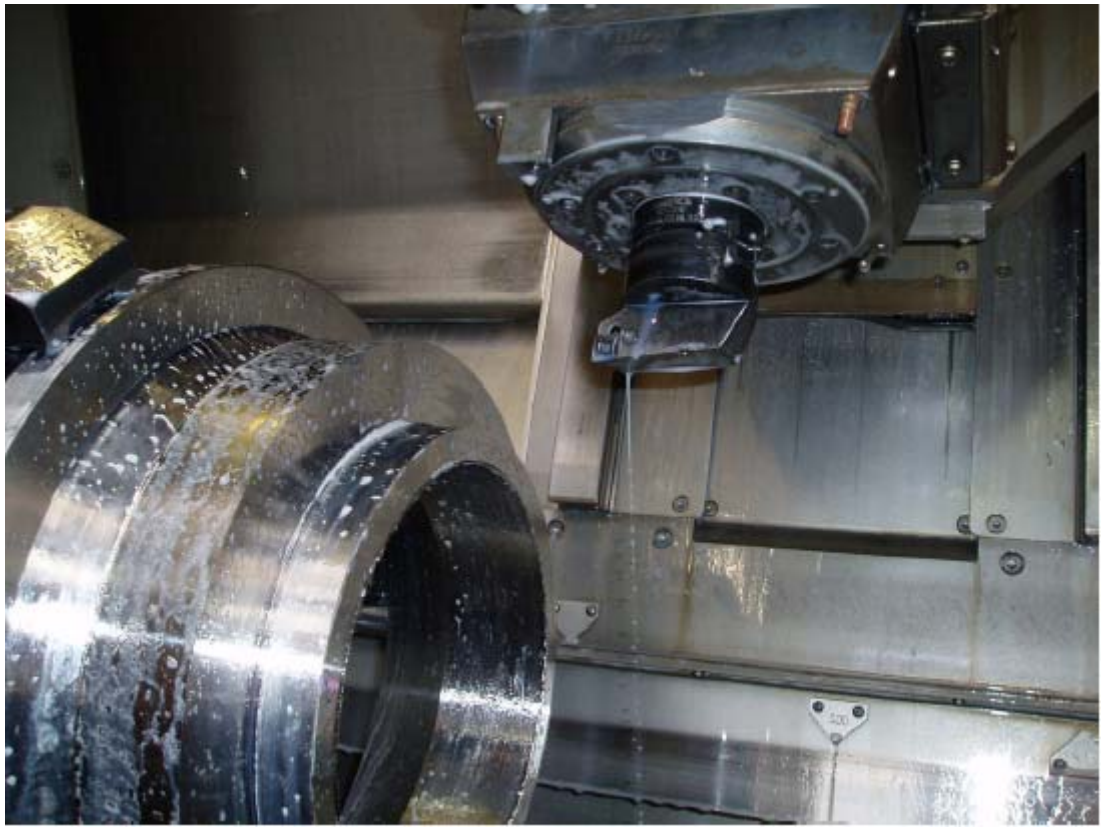


客户经验 –涡轮盘车削

- 用**Jetstream Tooling™**进行涡轮盘加工的加工总节拍
- 总时间节约 **240min**
- 提高机床使用率



客户经验 – Nimonic （镍铬钛铝合金）车削

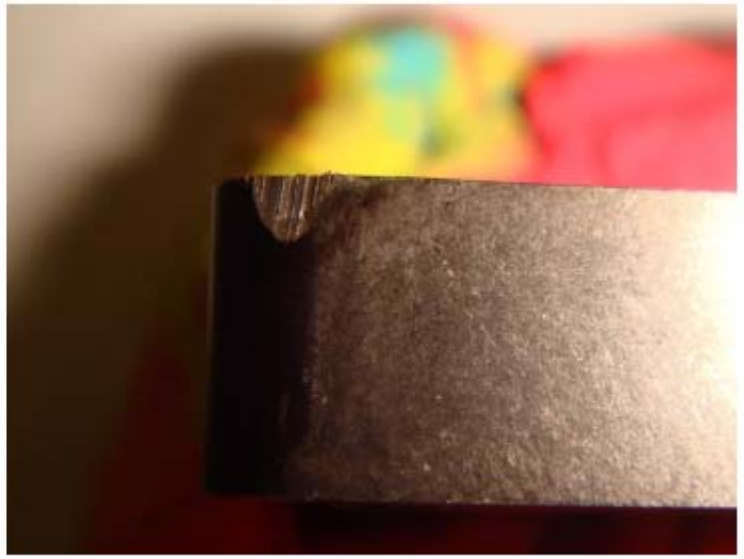


客户经验 – Nimonic 车削

- 车削 **Nimonic 263**
- **v_c = 220m/min**
- **f = 0.2 (0.25)mm**
- 传统刀杆
- **8bar**

传统刀杆
80bar (= 仅压力)

te: 2,95 min. ; VB: 2,0 mm.



te:2,95 min. ; VB: 1,1 mm.

车削 – Nimonic 车削

- 车削 **Nimonic 263**
- **v_c = 220m/min**
- **f = 0.2 (0.25)mm**
- **Jetstream Tooling™ 80bar (= 压力和方向)**

- **Te = 2.95min ; VB = 0.35mm**

Seco Jetstream Tooling™

SMG 11 (X2CrNiMoN22-5-3)

CNMG120412-MF4, TM4000

v_c = 100m/min, f = 0.25mm, a_p = 1.5mm

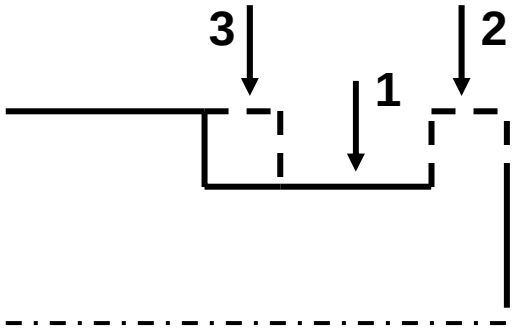
7bar

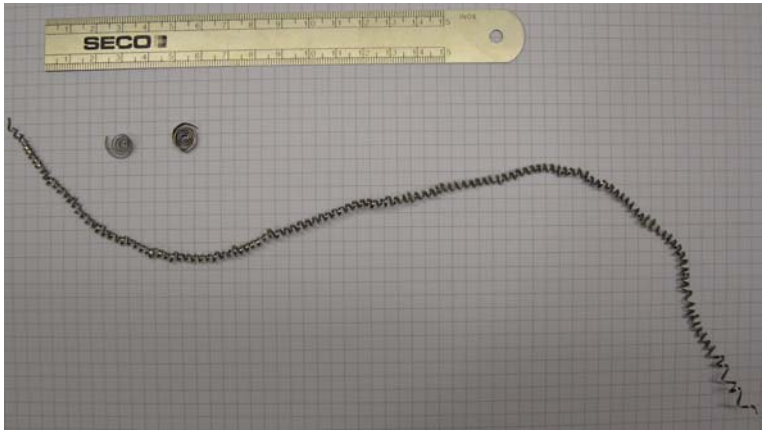
70bar

Seco Jetstream Tooling™

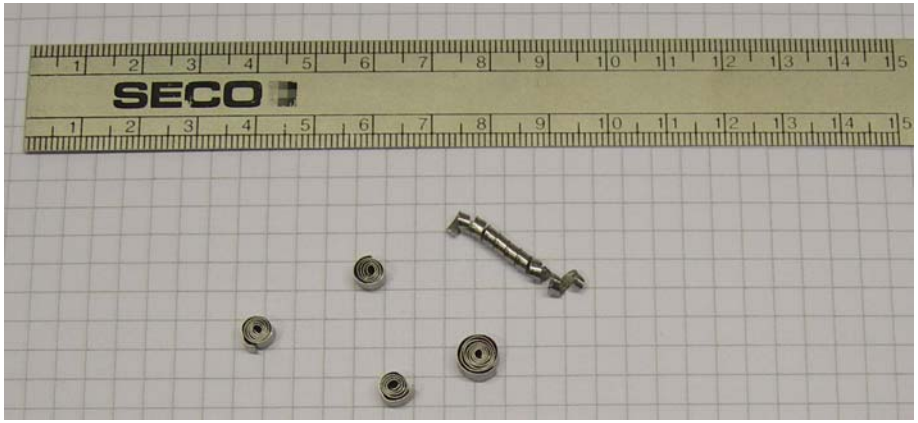
SECO 工件材料组 9 (X2CrNiMo17-13-2)
用Seco MDT割槽
CFIL2525M04JET **LCMF160404-0400-FT, CP500**
v_c = 170m/min **f = 0.12mm** **a_e = 4.0 + 2.0 + 2.0mm** **a_r = 5mm**

外冷却 7bar





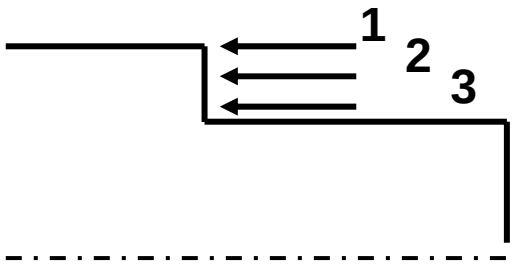
Jetstream Tooling™ 70bar
(17 l/min)

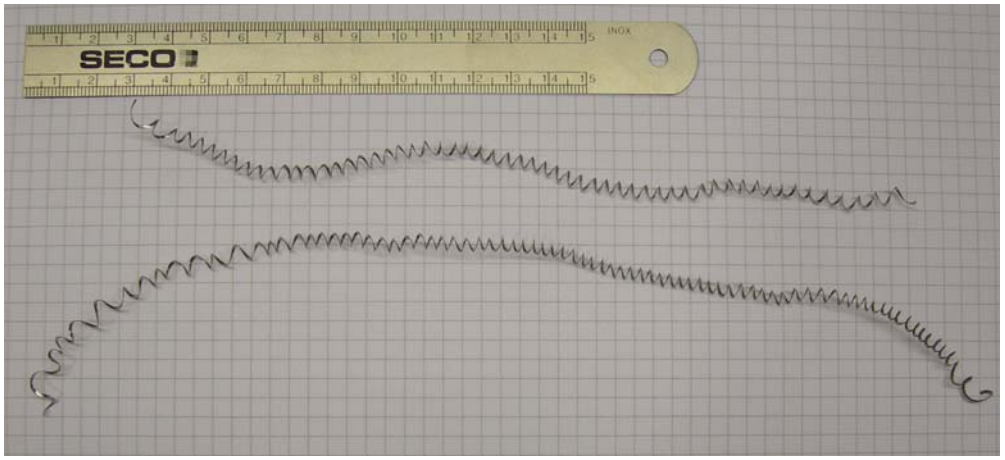


Seco Jetstream Tooling™

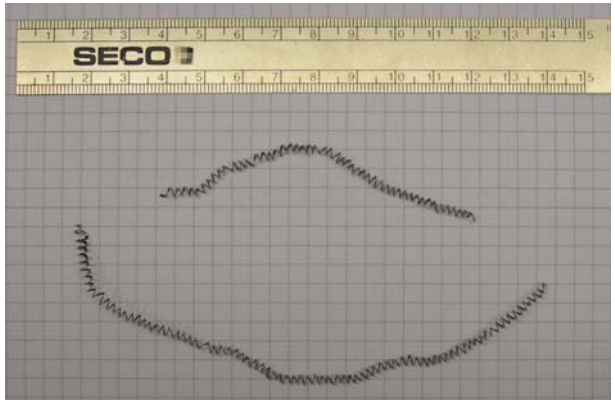
SECO 工件材料组 9 (X2CrNiMo17-13-2)
用 ISO刀片车削
PCLNL3225P12JET　　CNMG120404-MF1, CP500
v_c = 190m/min　　f = 0.1mm　　a_p = 0.5mm * 3

外冷却 7bar





Jetstream Tooling™　70bar
(17 l/min)



Market promotion project
Xian Laite Aero Engine

Workpiece: Casing
Material: Inconel 718 HRC 40
Machine:
Horizontal Turning Machine 20 bar
Existing insert:
DNMG150612-TF IC901/IC20 XXXXX

Existing Cutting data:
Vc = 25 m/min;
Ap = 0.5—1.0 mm;
f = 0.2 mm/r;

Cutting life time is
About 20-25 min with
A lot of long chip

Market promotion project
Xian Laite Aero Engine

We test with our tailor made cooling device with 40-50 bar
Testing tool holder from SECO:
PDJNR3225P15 JET
Testing insert from SECO:
DNMG150612-MF3, CP250
Existing Cutting data:

Vc = 40-60 m/min;
Ap = 0.5—1.0 mm;
f = 0.2 mm/r;

Cutting life time is also about 20-25 min but with very short and good chip

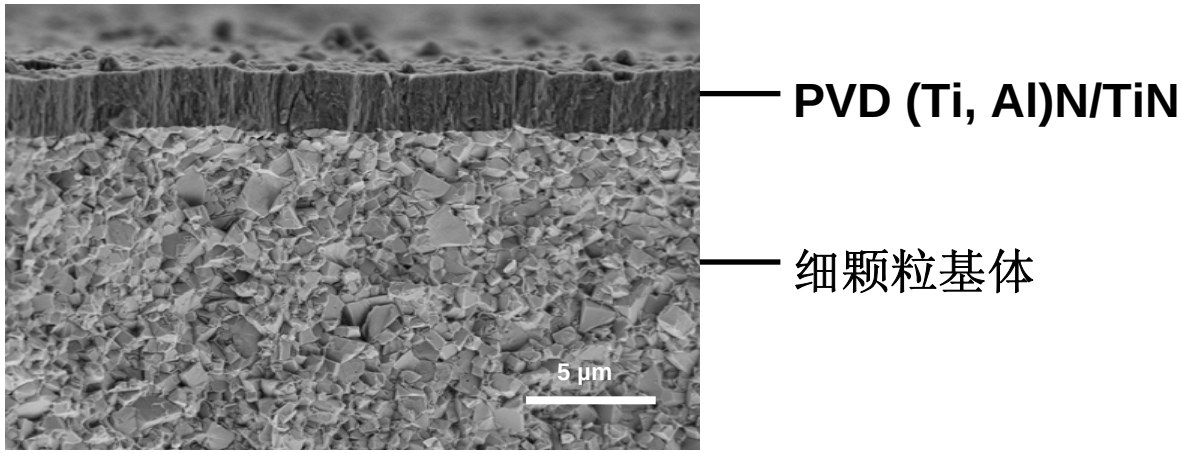
车削耐热合金

Triple-Zero™ 新材质等级 TS2000 & TS2500

专门用于车削耐热合金

针对ISO-S 材料的两种材质等级

- 两种专用于车削耐热合金的新型 **PVD-**镀层的细颗粒材质等级



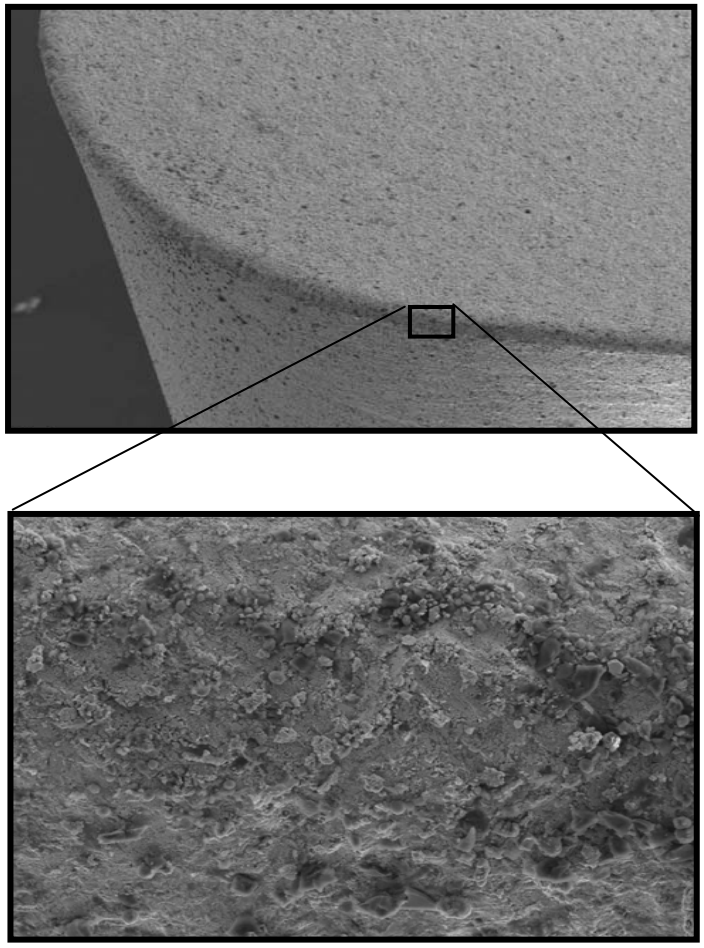
- **TS2000** 是针对高生产率、半精加工和高速加工的首选
- **TS2500** 是针对经济性好的粗加工、中粗加工、断续切削和高应力的首选

技术含量

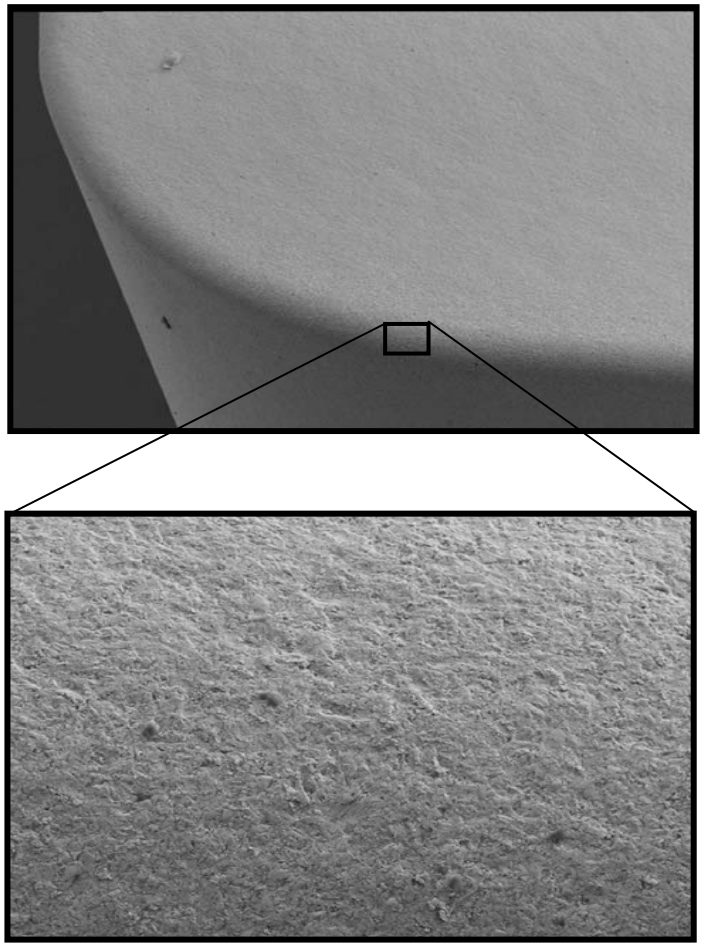
- 沉积前的新型切削刃修磨和表面处理提高切削刃的完整性
  - 表面形态
  - 镀层的粘附力
  - 切削刃廓形
- 新型PVD沉积的实施提高耐磨性
  - 镀层厚度
- 新材质等级致力于提高加工性能和可靠性
  - 刀具寿命
  - 生产率
  - 表面完整性

表面形态的改善

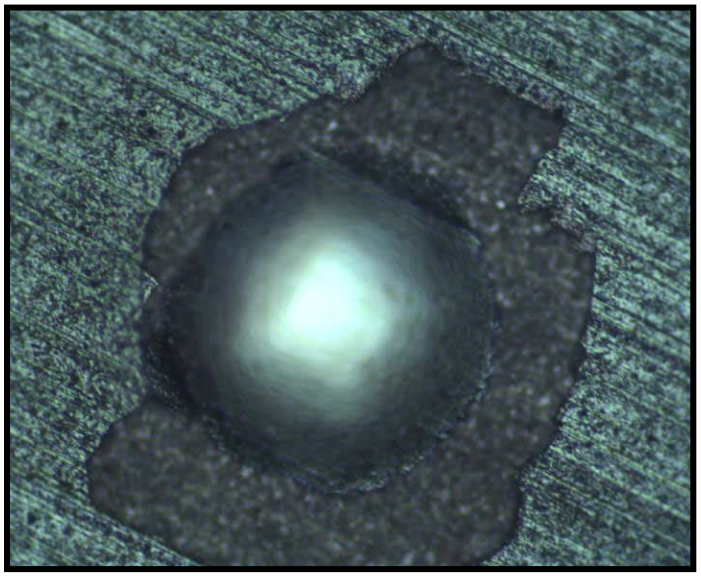
参照物: 现有的切削刃修磨，未镀层



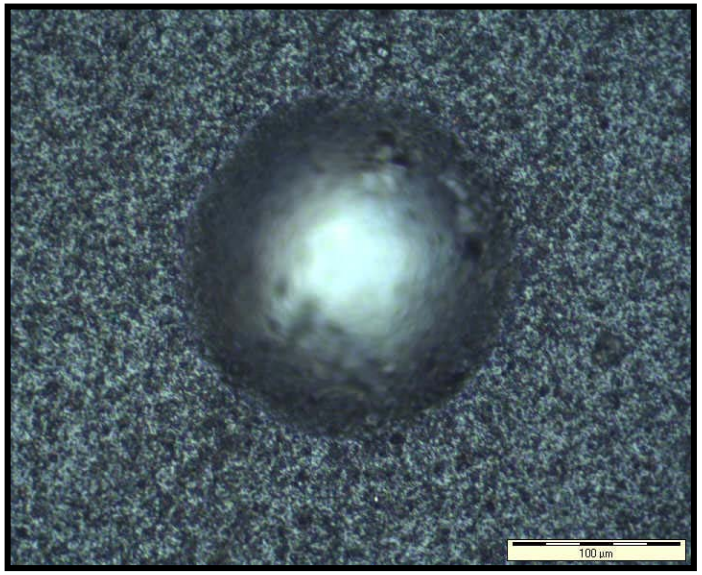
TS2000: 新型切削刃修磨, 未镀层



镀层粘附力的提高



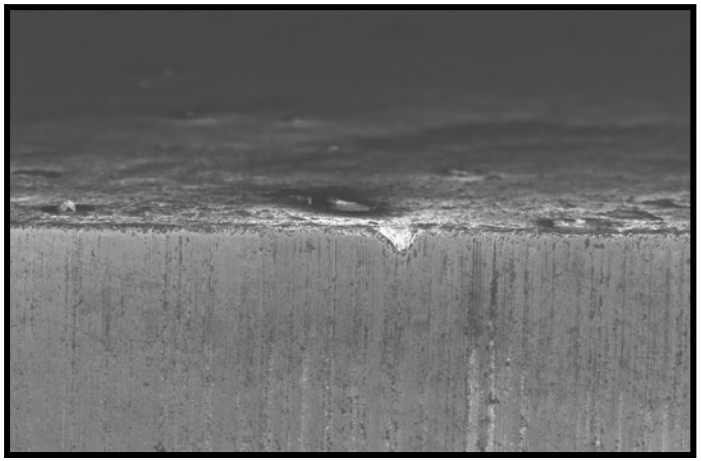
经磨削和镀层的表面。
沿洛氏硬度压痕的片状剥落。



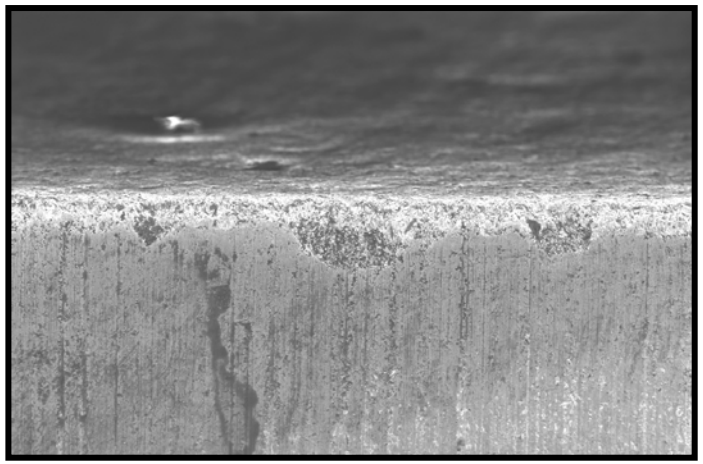
经磨削和镀层的表面。
磨痕被新型切削刃修磨去除。

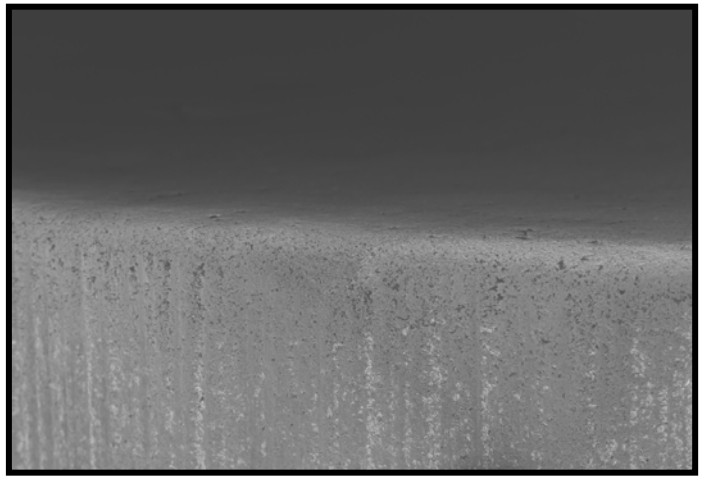
改善切削刃完整性

磨削刀片



现有切削刃修磨的刀片



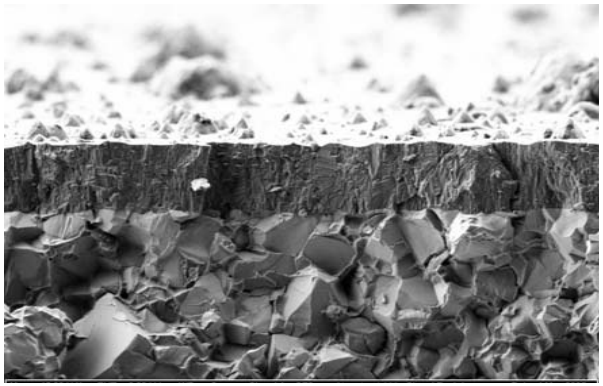


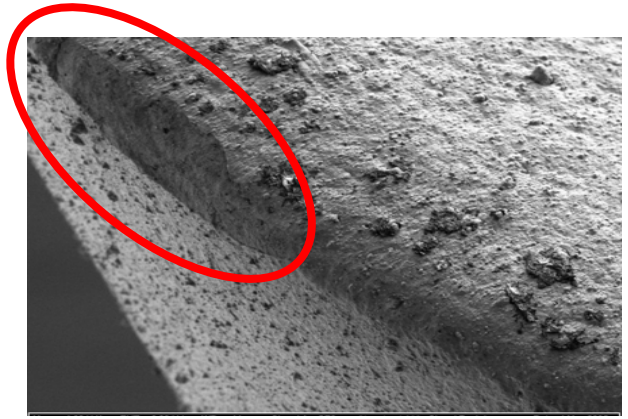
TS2000 具有新型的切削刃修磨。

增加的PVD-镀层厚度

当前的技术

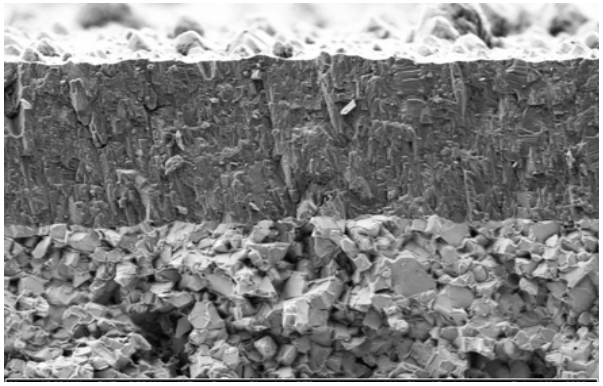
2-4 µm

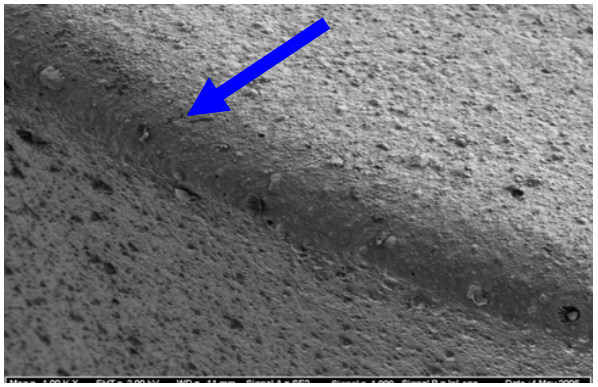




新的镀层工艺

6-8 µm

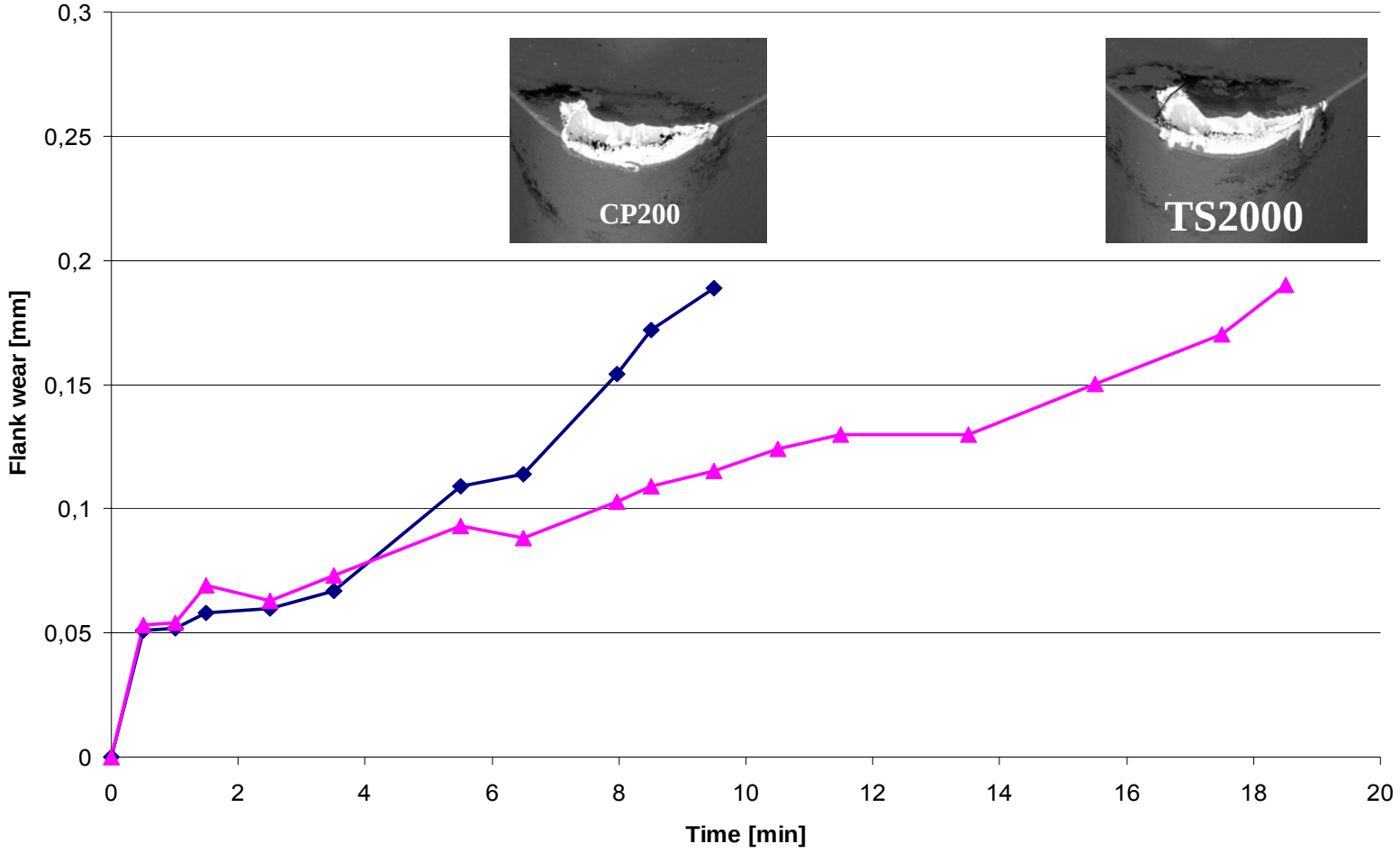




试验报告

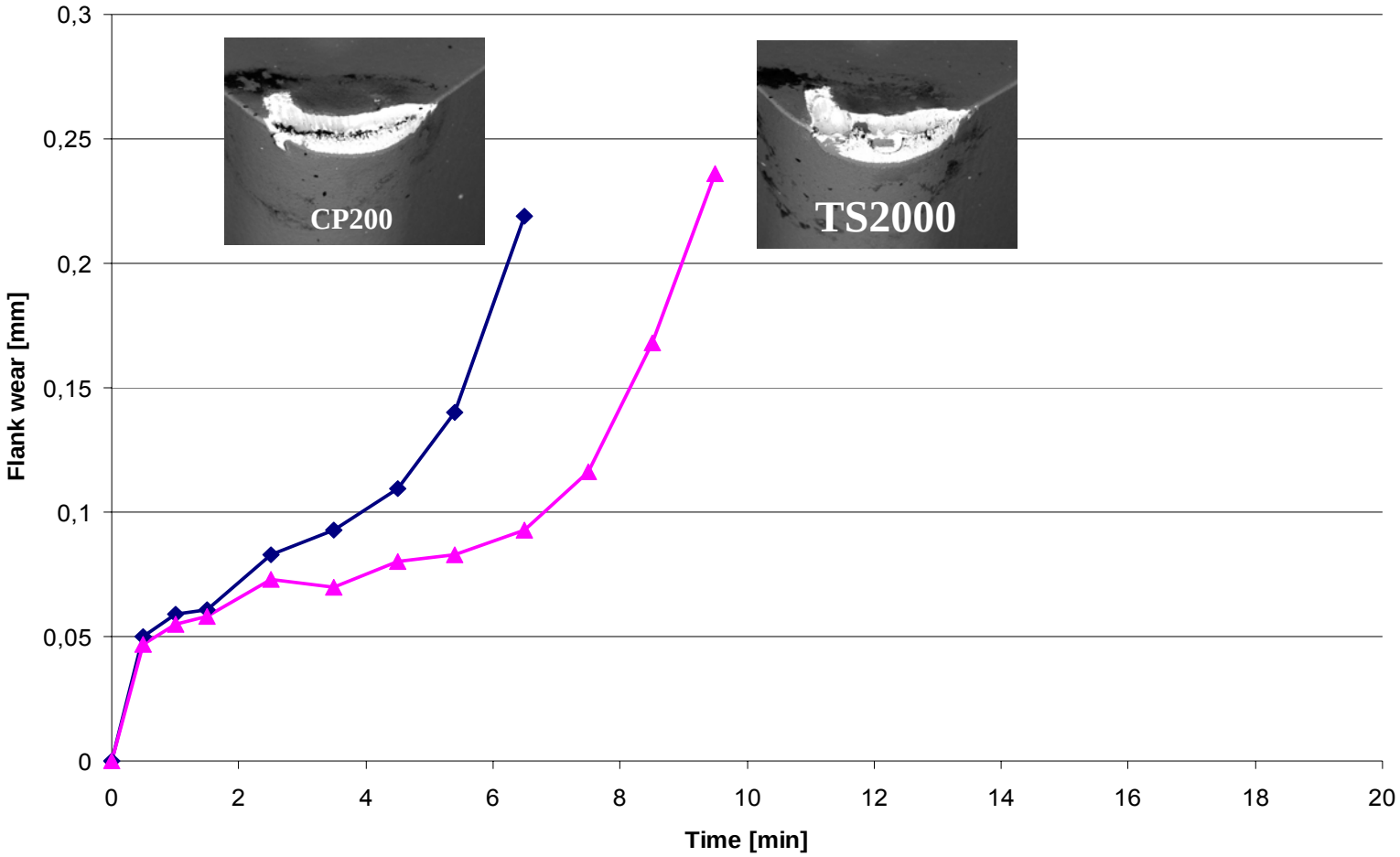
客户试验报告表现出提高的刀具寿命和速度能力

提高刀具寿命



v_c=55m/min f=0,25 mm/rev a_p=0,7 mm, Inconel 718 38-42 HRC

提高速度能力

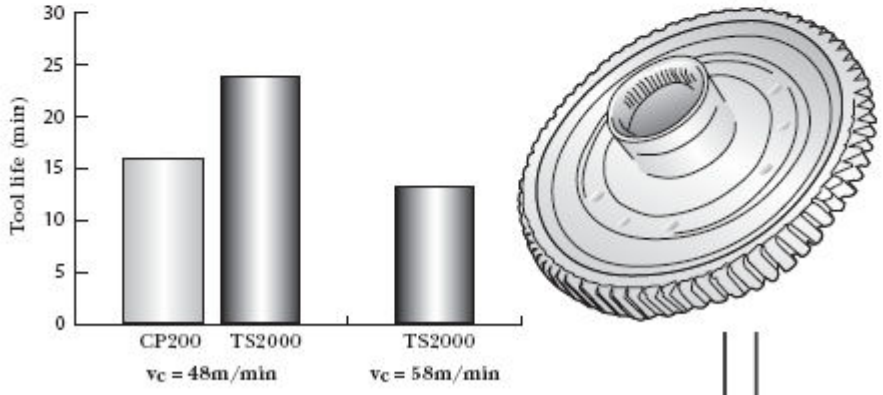


v_c=70m/min f=0,25 mm/rev a_p=0,7 mm, Inconel 718 38-42 HRC

客户试验报告

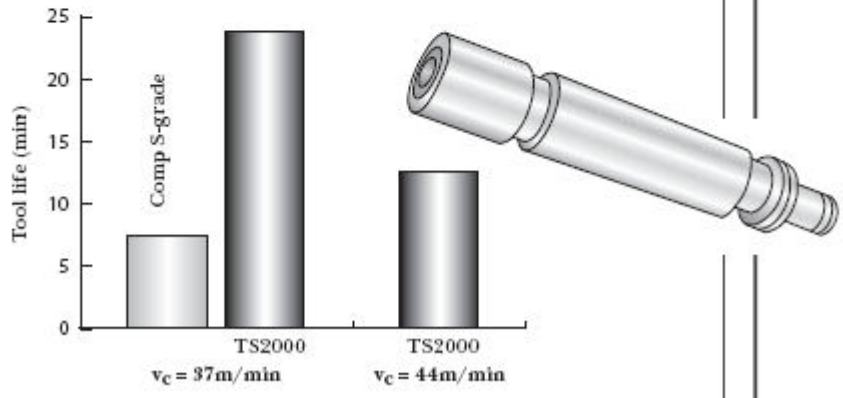
INCONEL 718 - (38-42 HRc) - TS2000

Operation	External Turning	
Component	Turbine Fan Disc	
Material	Inconel 718 (38-42 HRc)	
Insert	CNMG120408-MF1, TS2000	
	CNMG120408-MF1, CP200	
Cutting data	v_c	48 & 58 m/min
	f	0.15 mm/rev
	a_p	0.25 mm
	Coolant	Yes
Change criteria	Flank Wear	
Results	Tool life +33% or Productivity +20%	



INCONEL 718 - (38-44 HRc) - TS2000

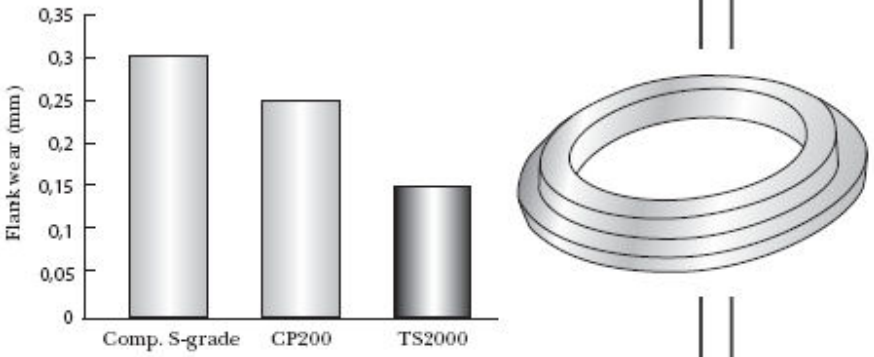
Operation	Internal Turning	
Component	Neutron Insert	
Material	Inconel 718 (38-44 HRc)	
Insert	CNMG120408-MR3, TS2000	
	CNMG120408-xx Competitor S-grade	
Cutting data	v_c	37 & 44 m/min
	f	0.25 mm/rev
	a_p	2.0 mm
	Coolant	Yes
Change criteria	Flank Wear	
Results	Tool life +200% or Productivity +20% and Tool life +100%	



客户试验报告

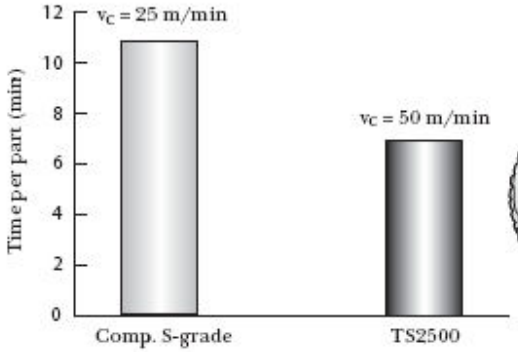
NIMONIC C263 - TS2000

Operation	Facing & External Turning	
Component	Ring	
Material	Nimonic C263 (Precipitation Hardened)	
Insert	CNMG120408-MF1, TS2000	
	CNMG120408-xx Competitor S-grade	
	CNMG120408-MF1, CP200	
Cutting data	v_c	50 m/min
	f	0.25 mm/rev
	a_p	0.3 & 0.9 mm
	Coolant	Yes
Change criteria	Flank Wear after 6 min in cut	
Results	Reduced flank wear and improved tool life.	



INCONEL 718 - (38-42 HRc) - TS2500

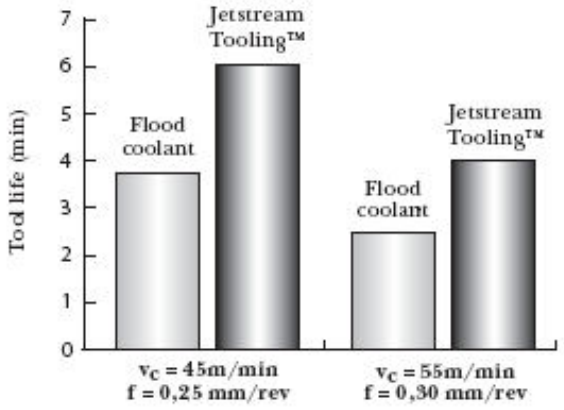
Operation	Rough Internal Turning	
Component	Turbine Fan Disc	
Material	Inconel 718 (38-42 HRc)	
Insert	CNMG120408-MR4, TS2500	
	CNMG120412-xx Competitor S-grade	
Cutting data	v_c	25 & 50 m/min
	f	0.25 mm/rev
	a_p	2.0 mm
	Coolant	Yes
Change criteria	Flank Wear 0.2 mm	
Results	Speed capability +100% and Cycle time -35%	



客户试验报告

JETSTREAM TOOLING – TS2000

Operation	External Rough Turning	
Component	Ring	
Material	Inconel 718 (38-42 HRc)	
Insert	CNMG120408-MF1, TS2000	
Cutting data	v_c	45 & 55 m/min
	f	0.25 & 0.30 mm/rev
	a_p	2.0 mm
	Coolant	Flood coolant
		High pressure coolant (p = 70 bar)
Change criteria	Flank Wear 0.3 mm	
Results	Tool life +50% or Productivity +25%	



- **Jetstream Tooling** 把高压的冷却液射流以高速直接传送到切削刃
- 该射流抬升切屑，使其离开前刀面，改善切屑控制并有效地把热量带离切削区
- 使用新型**TS-**材质等级和**Jetstream Tooling**的理念有助于提高刀具寿命并采用更高的切削参数

Questions?