Cutting Tool Solutions
For New Automotive Materials

Muneer Uddin
Global Automotive Portfolio Manager

3rd International Seminar on Modern Cutting & Measuring Engineering
Shenzhen, China
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KENNAMETAL®

Kennametal Partners

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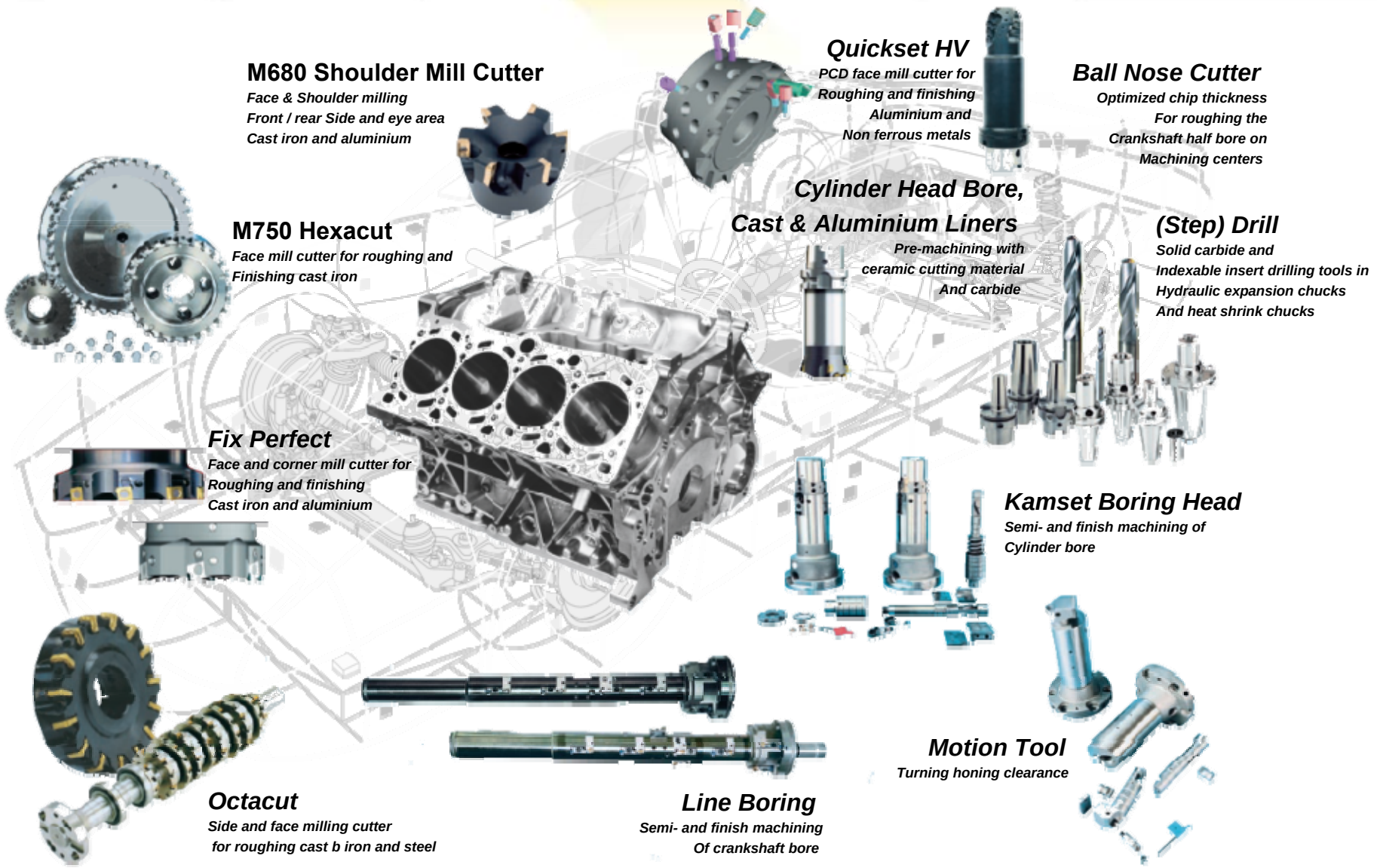
CGI Block Portfolio



M680 Shoulder Mill Cutter

Face & Shoulder milling
Front / rear Side and eye area
Cast iron and aluminium

Quickset HV

PCD face mill cutter for
Roughing and finishing
Aluminium and
Non ferrous metals

Ball Nose Cutter

Optimized chip thickness
For roughing the
Crankshaft half bore on
Machining centers

M750 Hexacut

Face mill cutter for roughing and
Finishing cast iron

Cylinder Head Bore, Cast & Aluminium Liners

Pre-machining with
ceramic cutting material
And carbide

(Step) Drill

Solid carbide and
Indexable insert drilling tools in
Hydraulic expansion chucks
And heat shrink chucks

Fix Perfect

Face and corner mill cutter for
Roughing and finishing
Cast iron and aluminium

Kamset Boring Head

Semi- and finish machining of
Cylinder bore

Octacut

Side and face milling cutter
for roughing cast b iron and steel

Line Boring

Semi- and finish machining
Of crankshaft bore

Motion Tool

Turning honing clearance

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COMPACT GRAPHITE IRON

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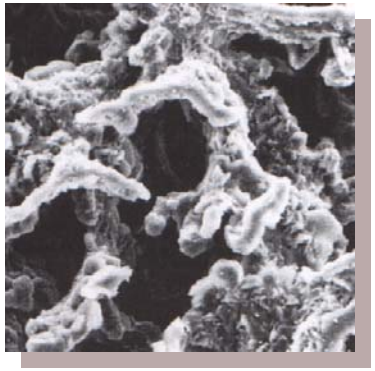
Machining Comparison GG:CGI

- CGI has roughly 50% higher tensile strength and elongation compared to gray cast iron.
- Efficient machining of CGI requires specific optimized cutting parameters, different from those used in gray cast iron machining

Gray Cast Iron

Compacted Graphite Iron



Property	Gray Iron *GG 35B*	CGI *GGV*
Hardness (Brinell)	160-235 HB	180-250 HB
Tensile Strength (MPa)	220-350	300-500
Elastic Modulus (GPa)	105	145
Fatigue Strength (MPa)	110	210

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Process Equipment Selection for CGI

- Typical power requirements for CGI are ~30% higher than GCI
- High spindle power necessary especially for roughing operations (up to 50 kW spindles)
- Compared to GCI, cutting speeds are lower and resultant forces are higher for comparable chip load, requiring high spindle torque at low to moderate speeds.
- Tool life is generally 30 % less than GCI

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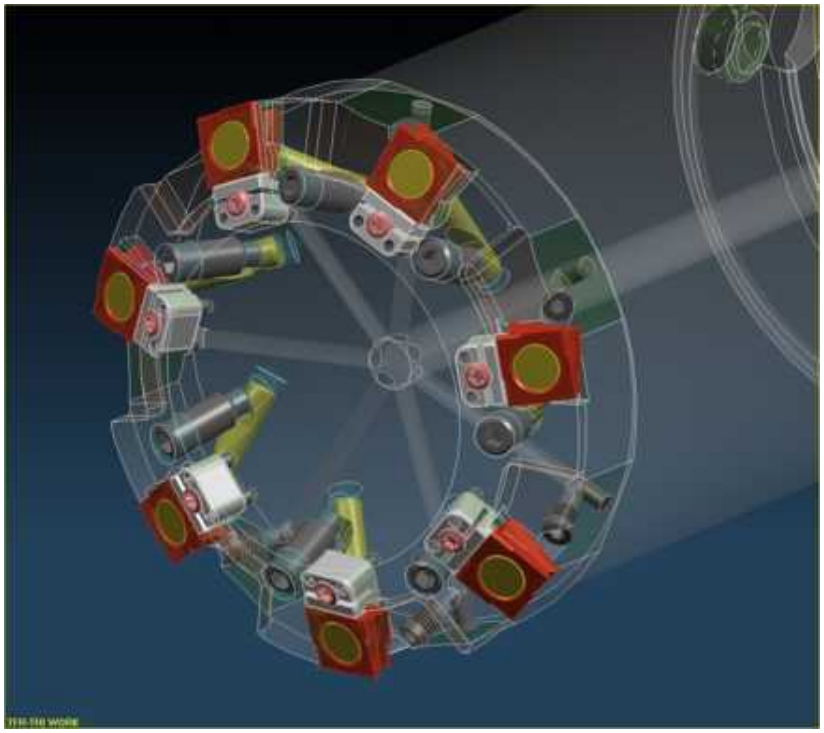
Cylinder Boring – Proven Solution

Challenge

Decrease the number of spindles to rough cylinder bore CGI block by 50%
Material not capable of being machined using ceramics or CBN (proven in KMT R&D Lab)

Solution

- **Increase number of inserts from 4 to 7 using Fix Perfect design**
- **Increase velocity to 160 MPM, 2.1 mm/rev**
- **Obtain tool life of 600 bores**
- **Use matrix grade SP87EM carbide developed for machining CGI**
- **Effectively cut time by more than half to allow for decrease in number of spindles**



Proven Solution

Delivering 50 % Reduction in Spindles

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CGI Block: Roughing Cylinder Bore

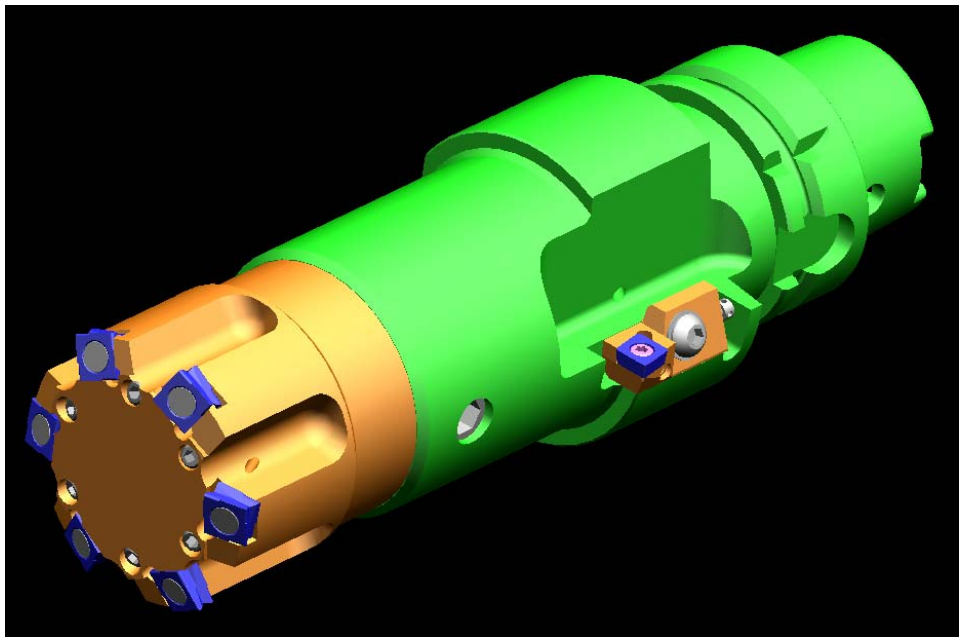
CI

The Task:

- Component: passenger car cylinderblock 4 cyl
- Material: CGI 450
- Operation: roughing d.o.c. approx 3 mm radially
- Coolant: internal
- Machine: Transfer Machine - 2 spindles

The Data:

v_c= 160 m/min
D = 78,5 mm; z = 6
f_z= 0.2 mm/insert
v_f = 631 mm/min



The Solution

- boring head with modified
  Fix Perfect inserts (8 edges); use R0,5 instead of standard edge. SP87EM carbide
- vibration damped adaptor with heavy metal
- one tool R.H. one tool L.H

The Result

- 600 workpieces
- cutting length 164 mm per cylinder = 100 m toollife (or 150min)

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Cylinder Bore - Finishing on Machining Centers

Cast Iron

Romicron HSC Fine Boring Tool

The Task:

- Component: passenger car cylinderblock
- Material: CGI 450
- Operation: fin. cylinderbore
- Coolant: Yes
- Machine: Heller MC
- Roundness: 6-8 µm
- Surface Quality: Ra 3.75 µm
- Roundness better 5 µm

The Data:

v_c= 130 m/min
D = 80 mm
f_z= 0..25 mm/tooth; z = 3
f = 300 mm/min

The Solution:

- Romicron Boring bar z=3, all 3 inserts adjustable at one time with scale ring

The Result:

- Ra 1,31 µm / Rz 7,14 µm
- Roundness between 3,7 and 4,9 µm

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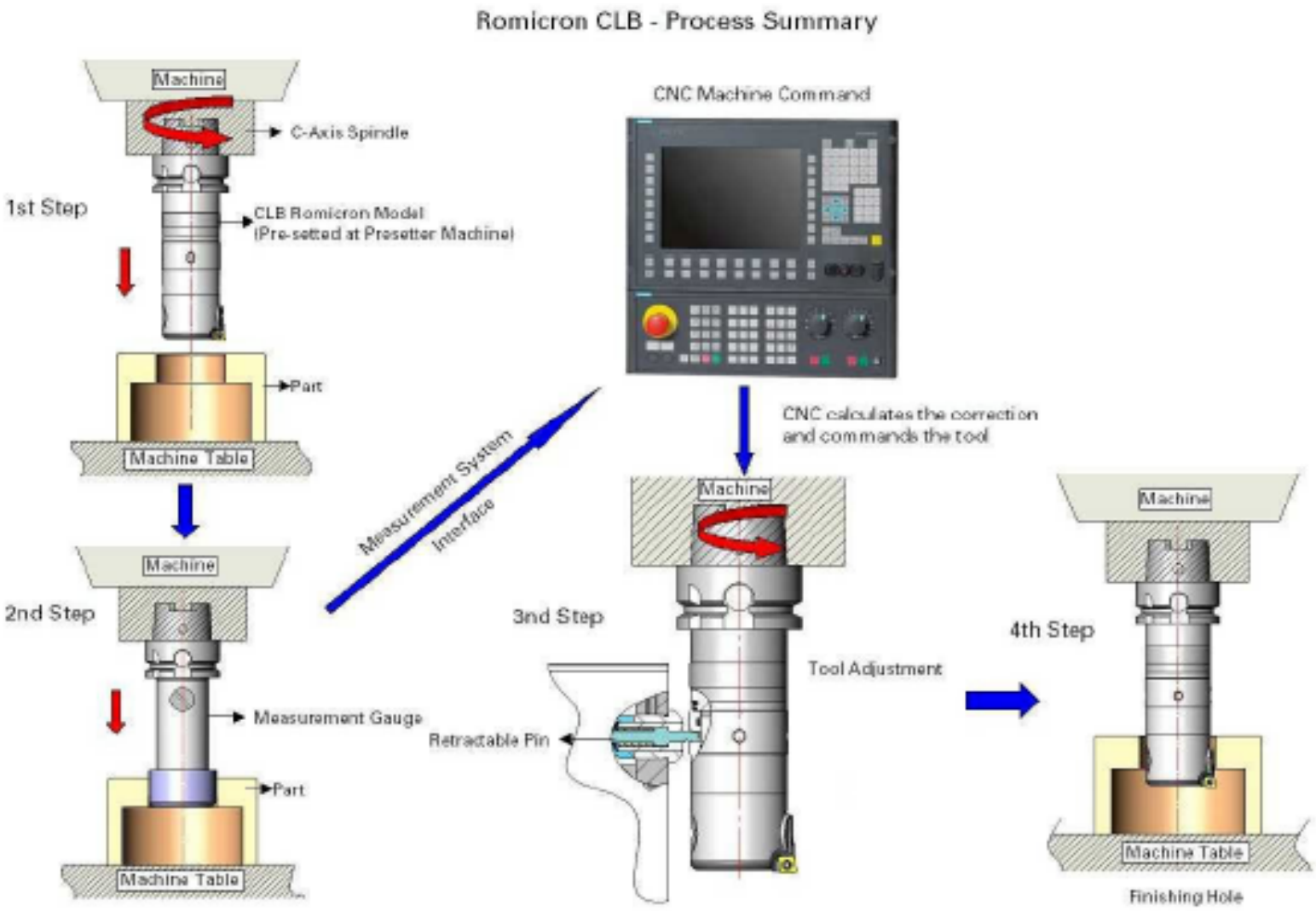
CLB - Process Solution with Romicron



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Milling CGI

CGI

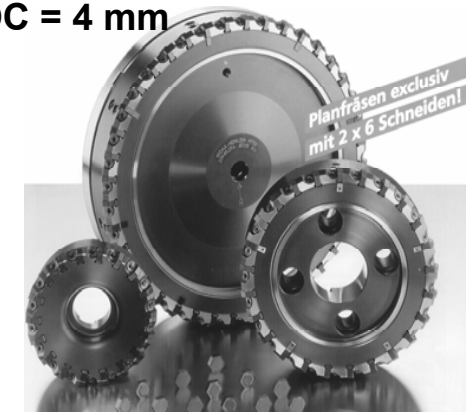
Roughing Engine Block - Head Face

The Task:

- Component: Pass. car V6/V8
- Material: GJV450 (Ti< 0,015%) 240 HB
- Operation: rough milling head face
- Coolant: no
- Machine: Transfer Line
- Rz = 20 µm

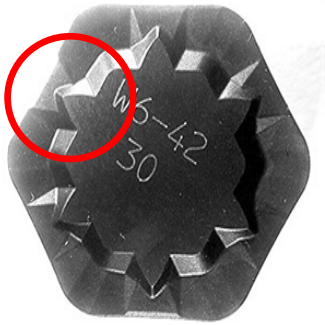
The Data:

- D = 315 mm, zeff = 46
- vc = 100 m/min
- FPT = 0,25 mm
- DOC = 4 mm

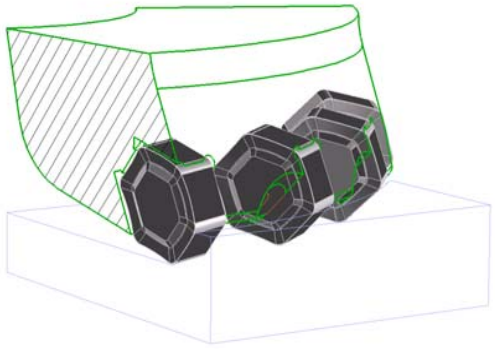


The Solution:

- milling cutter M750 (12 usable cutting edges / insert)
- HNGX 090520-MCI in TN-6510
- strengthend geometry in area of cast skin
- thin coating PVD
- Limitations/ specifics: rigid setup



HNGX 0905*230*-MCI



The Results:

- T = 900 blocks (1.800 faces) (breakouts)

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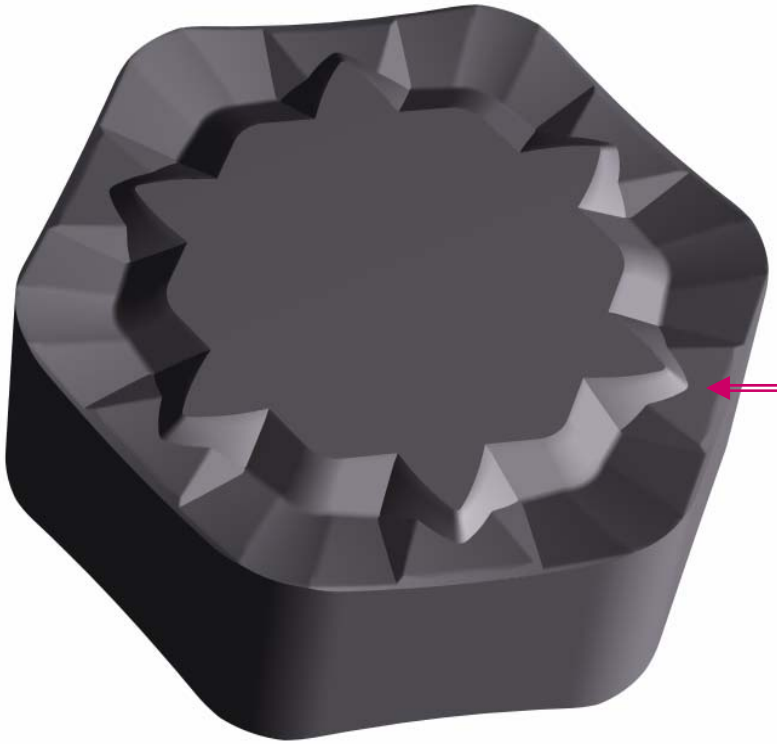
CGI - Milling

CGI

M 750 - MCI Geometry



Geometry for roughing preferably at κ_r = 45° with a_p = 3 - 4 mm

Main features:

- **Groove filled up in mid of edge**
- **Larger K-land in mid of edge**
- **10 µm stronger honing**

Benefit:
No notch wear

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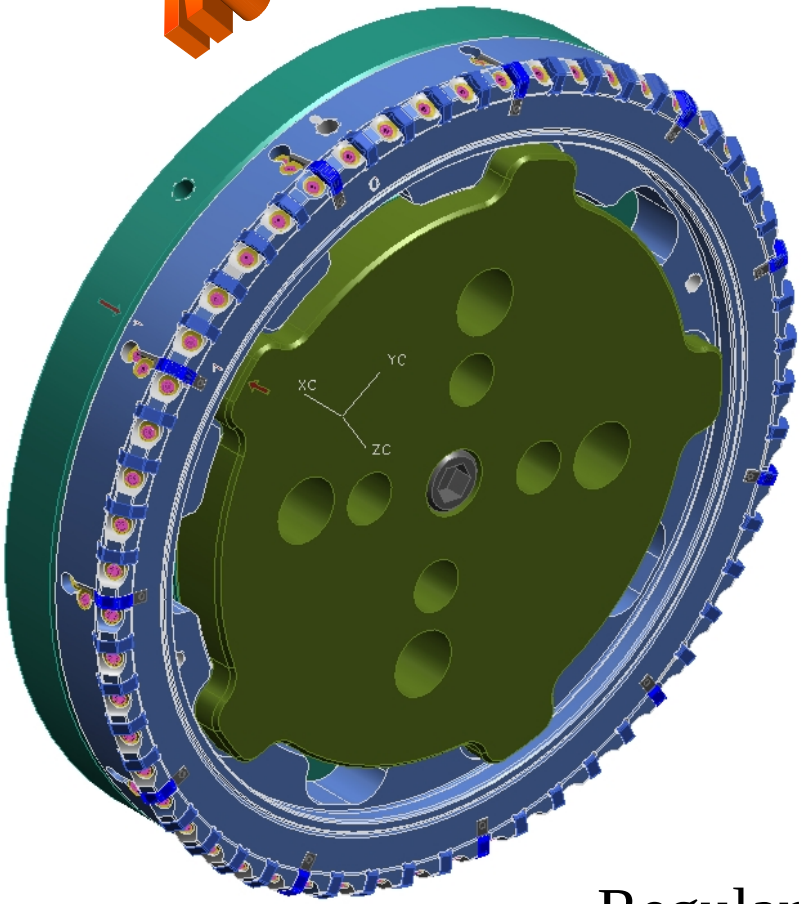
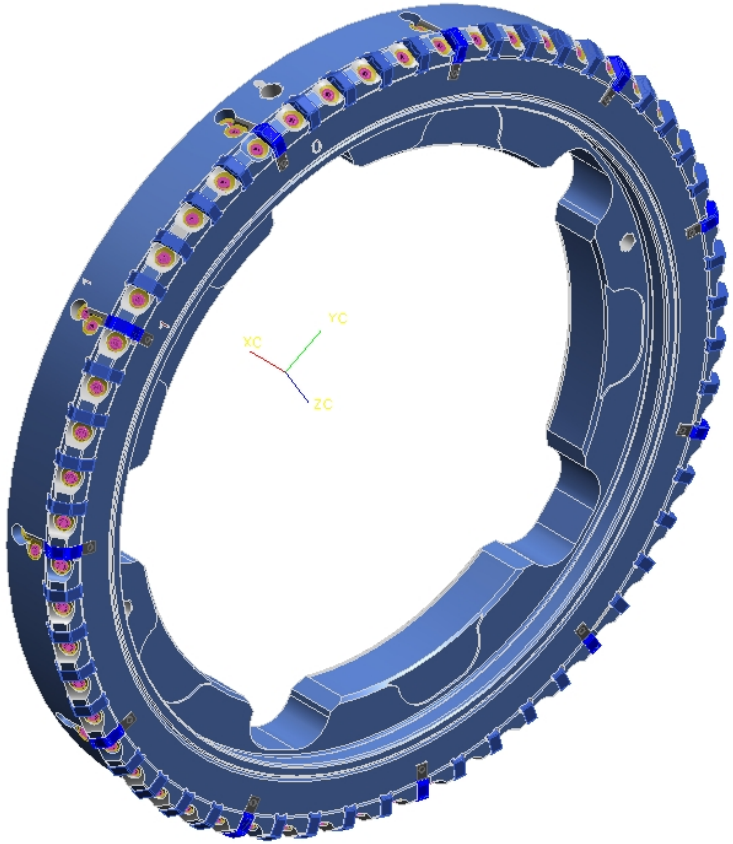
CGI - Milling Applications:

CGI

New:

M750 with Bajonett Adapter:





Regular Design !

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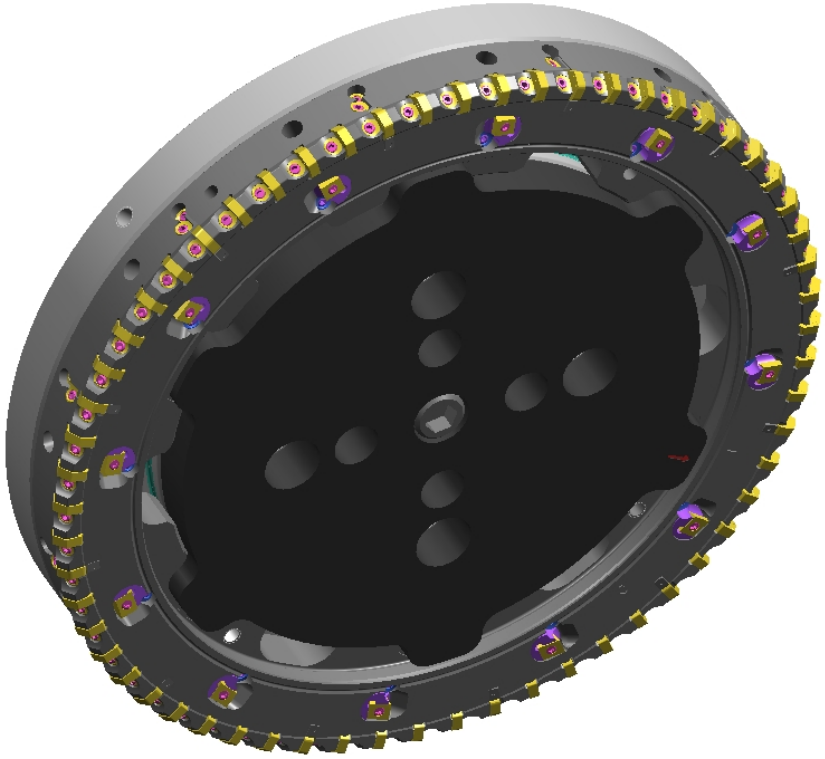
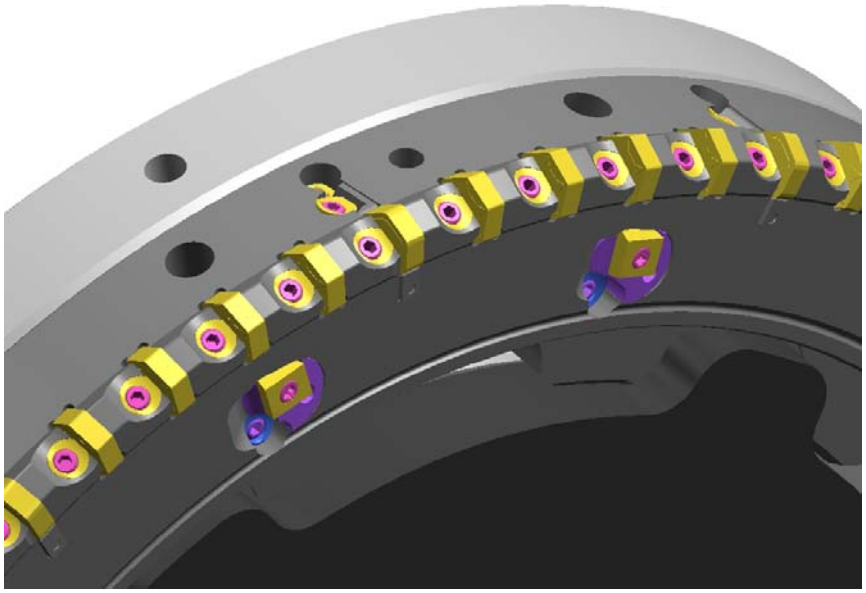
CGI - Milling Applications:

CGI

New:

M750 with Bajonett Adapter:





M641 Design with lateral mounted Wiper Inserts for higher Surface Requirements!

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Proven Solutions

Engine Block Machining

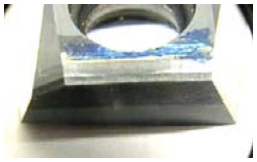
Aluminium

Bi-Metal

Face Mill M641 with Carbide Inserts

Bi-Metal

3



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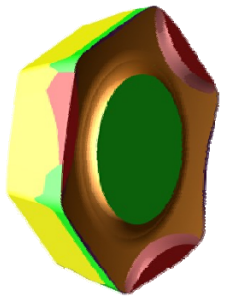


Carbide or PCD

21_003420_001

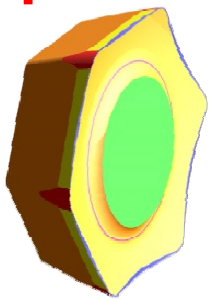
axially +0,03 vs. „2“

1

233 38 458 36

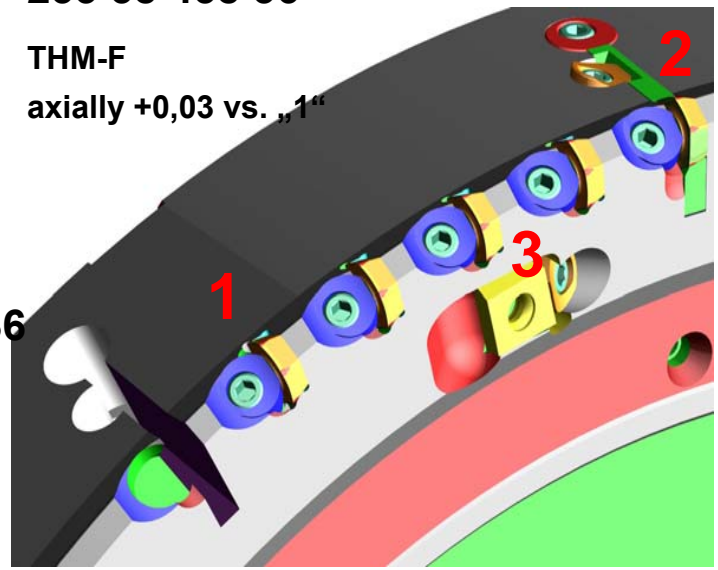
THM-F

axially +0,03 vs. „1“



233 38 457 36

THM-F



Features:

- Fine-grained carbide K01
- Thin PVD coating
- Polished chip faces
- Radially and axially positive geometry
- Flexibility pre- vs. final finish inserts
- Finishing inserts axially adjustable
- Minimum setting time
- PCD finisher is possible

Data:

- D = 400 mm, zeff = 60 (48x1+12x2+2x3)
- vc = 250 m/min, FPT = 0,11 mm, DOC = 0,5 mm
- Wt = 10µm, Rz = 2,99, Ra = 0,43
- T = 1.000 l4 blocks AlSi6 + GG26 (Spec)

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Engine Block: Deck Face Grinding

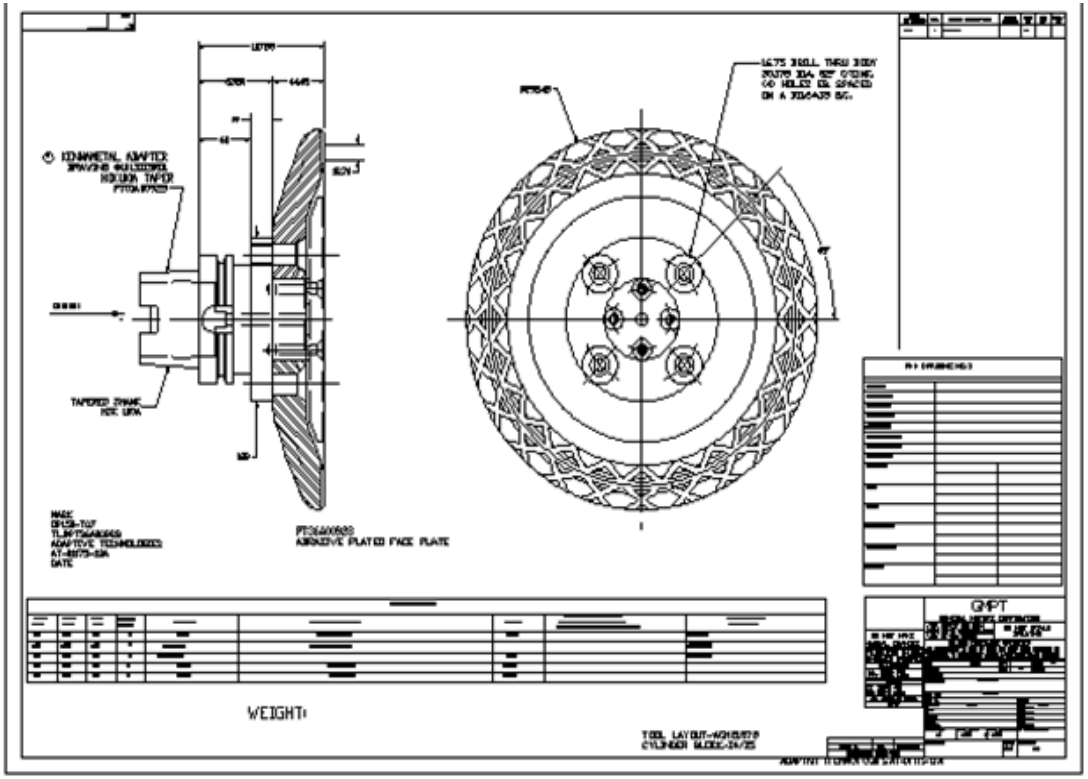
Bi-Metal

The Task:

- Component: Pass. Car I4I5 engine block
- Material: Aluminum 356 Loss Foam Cast with GG26 liners
- Operation: Deck Face Finishing
- Coolant: Yes
- Machine: HSK100A CNC HMC

The Data:

D = 298 mm
vc = 1500 m/min
F = 1600 mm/p/m
DOC = 0.05 mm



The Solution:

- CBN Plated Face Grinding Wheel
- Bi-Metal cut of AL+CI
- Can be replated
- Requires Semi-finish milling cutter
- See 1067544
- Use instead of PCD Milling cutter

The Results:

- Rz = 5.0
- T = 1000 blocks **Grinding Disc 1047989**

GDW 1047989; GM I4I5; NTC; Jerry Greenman

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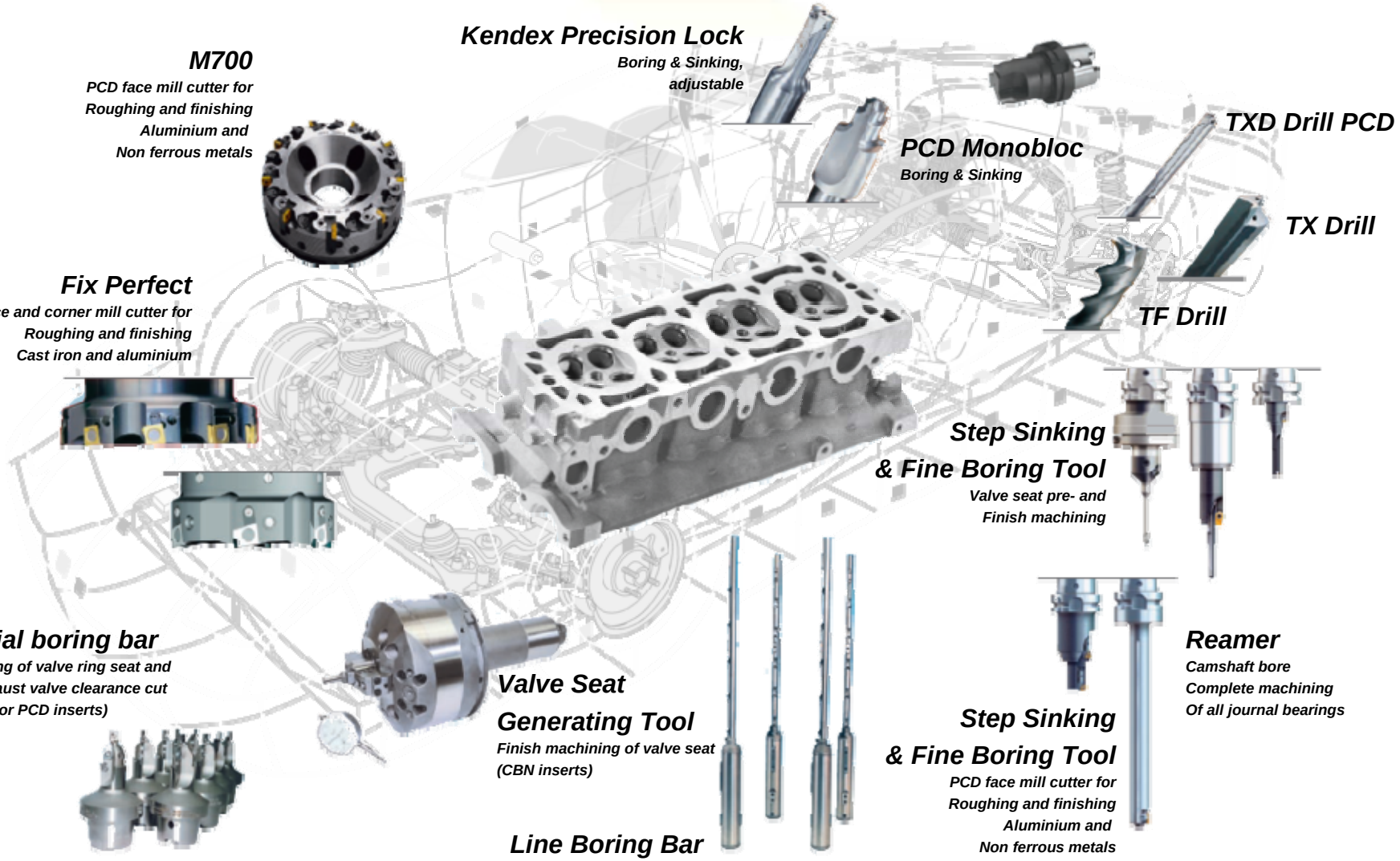
Cylinder Head Portfolio



M700
PCD face mill cutter for
Roughing and finishing
Aluminium and
Non ferrous metals

Kendex Precision Lock
Boring & Sinking,
adjustable

PCD Monobloc
Boring & Sinking

TXD Drill PCD

TX Drill

TF Drill

Fix Perfect
Face and corner mill cutter for
Roughing and finishing
Cast iron and aluminium

Step Sinking & Fine Boring Tool
Valve seat pre- and
Finish machining

Special boring bar
Pre-drilling of valve ring seat and
Inlet/exhaust valve clearance cut
(Carbide or PCD inserts)

Valve Seat Generating Tool
Finish machining of valve seat
(CBN inserts)

Reamer
Camshaft bore
Complete machining
Of all journal bearings

Step Sinking & Fine Boring Tool
PCD face mill cutter for
Roughing and finishing
Aluminium and
Non ferrous metals

Line Boring Bar
Finish machining of valve seat
(CBN inserts)

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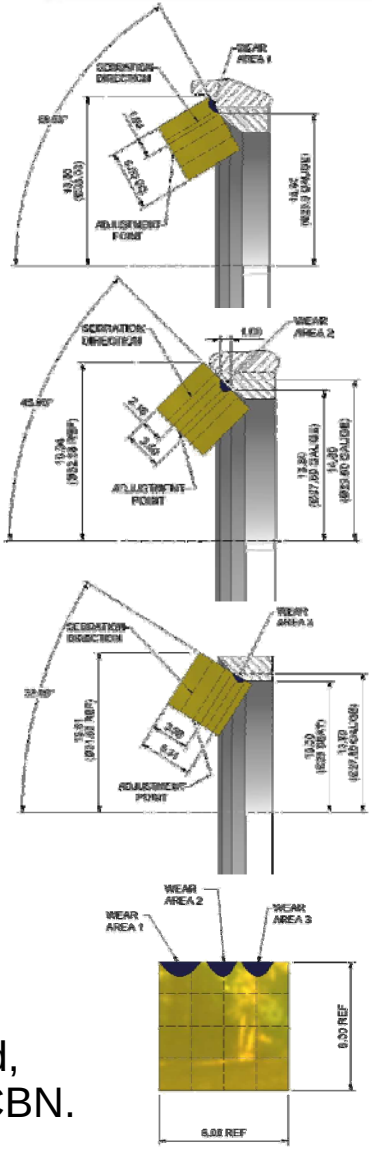
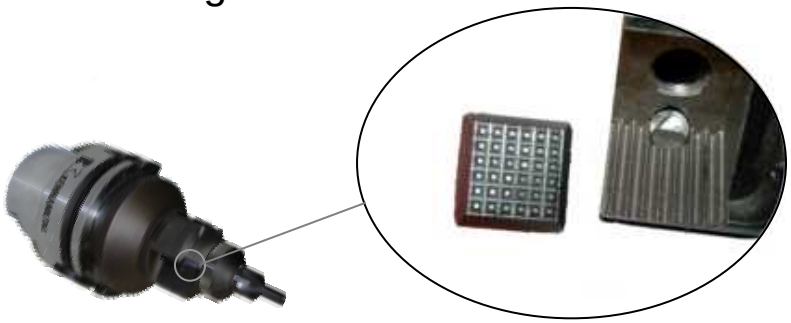
Valve Seat Machining

- No setting of valve seat angles; determined by serrations in body.
- Minimum length setting to achieve correct intersections.
- Positive clamping system gives insert stability.
- Clamp design prevents damage to cutting edges.
- 4 edges per seat insert reduces costs.
- Cost per part of 0.70 cents with expected tool life of 450 seats / edge
- Minimum or no setting of valve guide reamers depending on choice.
- Two piece design reduces reconditioning costs.
- Only 1 design of insert used



Transfer Line



Felxible CNC

- Standard (6, 9, 12mm)Insert available in Carbide, TiN Coated, TiCN Coated, TiAlN Coated, Cermet and full face PCD and CBN.

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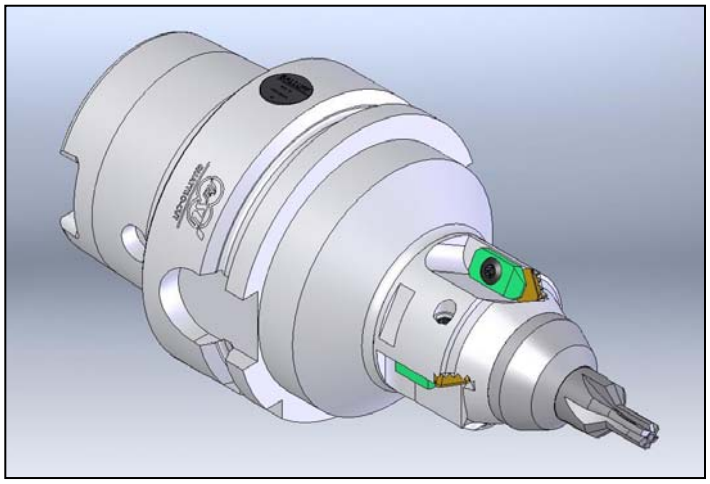
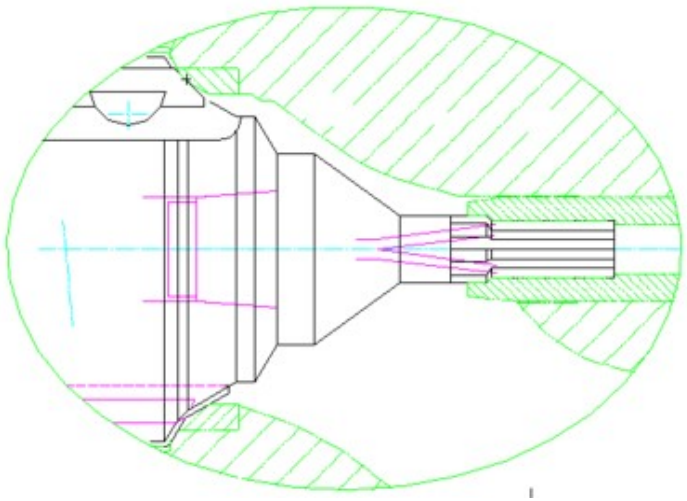
Valve Guide Machining (CNC)

- Finish Seat & pilot guide
- Tool life of seat - 4,800 intake seats or 2,400 exhaust seats
- Tool life of guide reaming - 44,000 holes s'finish (1/4th depth as finish)
- Tool Cost / pc of valve seat - $0.7 CBN (Hard seats) or $0.12 c.carbide
- Tool cost /pc of valve guide reamer - $0.002 s'finish (intake & exhaust)
- Approximate time for tool set up - 15 minutes cleanup/index/preset without removing reamer (add another 5 minutes for reamer change)





Proven Solution

Combined tool systems – Reducing tools & Eliminating Changes

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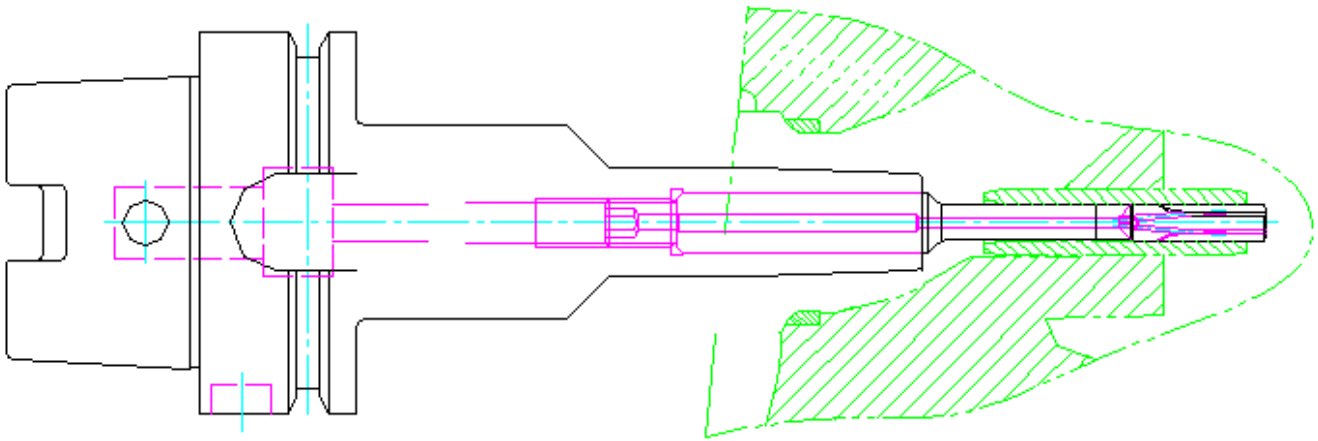
Valve Guide Machining (CNC)

- Tool life of guide reaming - 11,000 holes (all holes done with (1) reamer)
- Tool cost /pc of valve guide reamer - $0.02
- Approximate time for tool set up - 7 minutes cleanup/index/preset



Proven Solution

Combined tool systems – Reducing tools & Eliminating Changes

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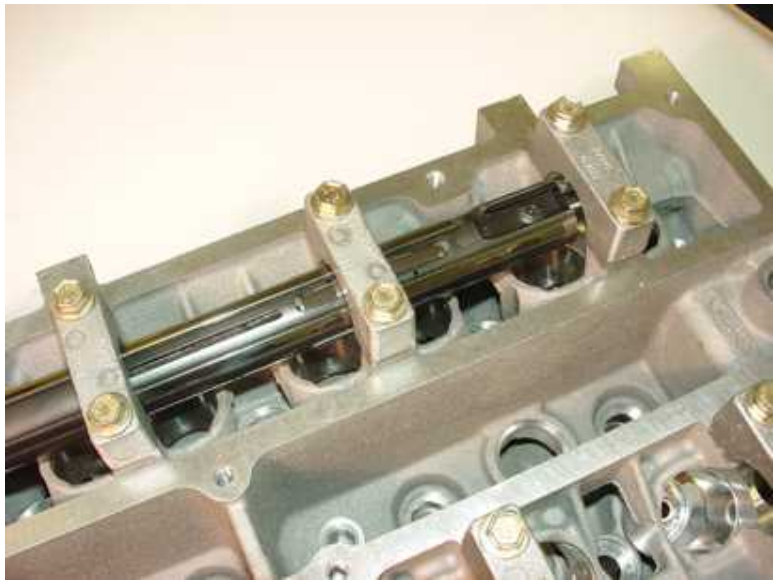
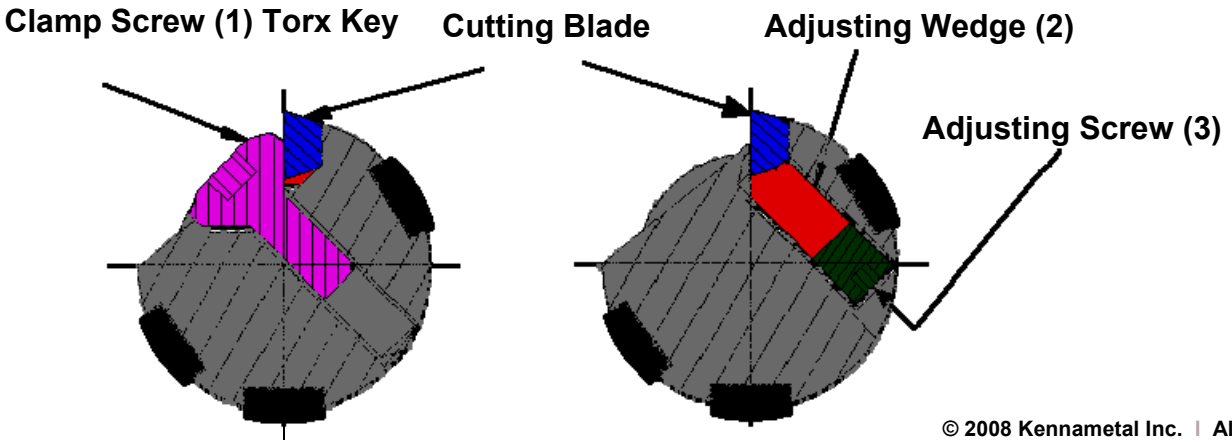
Cam Bore Tooling Benefits

Q-Cut Cam Bore Reamer



Advantages

- Gluing the pads allows full length carbide pad
- Repairing tools is simpler and more cost effective.
- Tools can be re-padded an unlimited amount of times.
- Gluing pads is a stable process reducing stress in the reamer body which increases the life of the reamer body, thus reducing cost.



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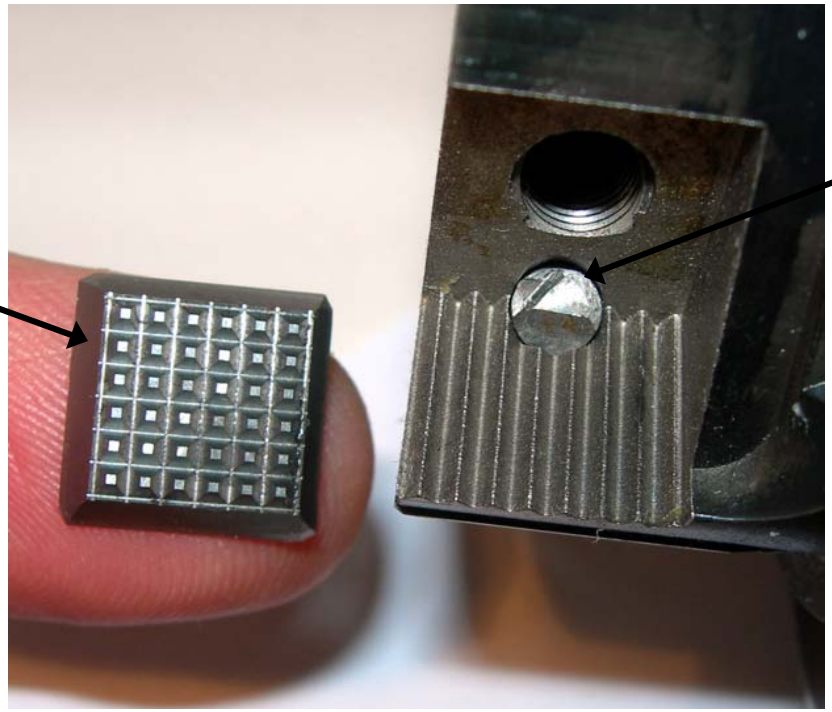
Advanced Solutions – Fine Boring

WHAT IS THE "QUATTRO-CUT" REAMER ?

4-edged indexable insert locates on precision serration's



Precise size control to microns but only 1 adjusting screw is required

Simple blade adjustment "de-skills" setting of the tool

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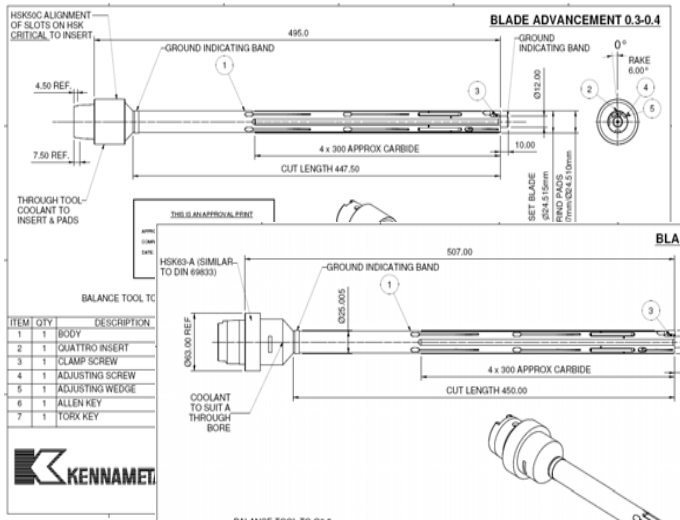
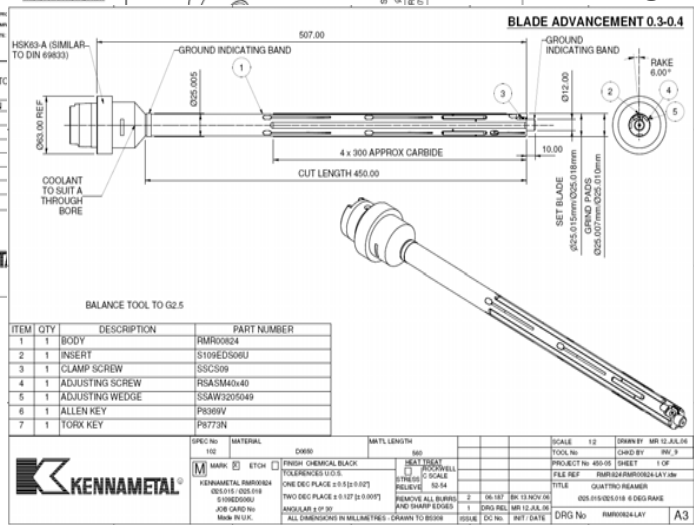
Typical Bore Finishing Cost Savings

Semi Finish



Finish



Detail	KMT	Competitor
New Cost :	£3,000	£5,000
Refurb Cost :	£2,000	£3,000
Insert cost :	£195	£130
Insert cost / edge :	£49	£130
Insert Matl :	PCD	PCD
Inserts / Tool :	1	1
Edges / insert :	4	1
Compt / Edge :	40,000	35,000 - 40,000
Compt / Insert :	160,000	35,000 - 40,000
Speed r.p.m. :	3500	3500
Speed m/min :	270	270
Feed mm/rev :	0,1	0,1
Feed mm/min :	350	350

PCD Aluminium Head Estimated
Cambore Savings = $50,000 per annum

Proven Solution

Creating value through superior tools & process focus

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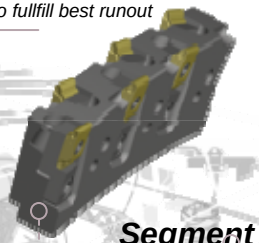
Crankshafts Portfolio

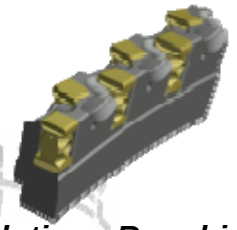
KENNAMETAL

300 Customers

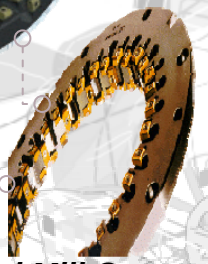
Segment Solution - Roughing
highest productivity
best Flexibillity

Segment Solution - Finishing
highly adjustable to fullfill best runout





Deep Hole Drill
for depth with 20 up to 30 times D
machining cast iron and steel



Segment Solution - Roughing
highest productivity
best Flexibillity

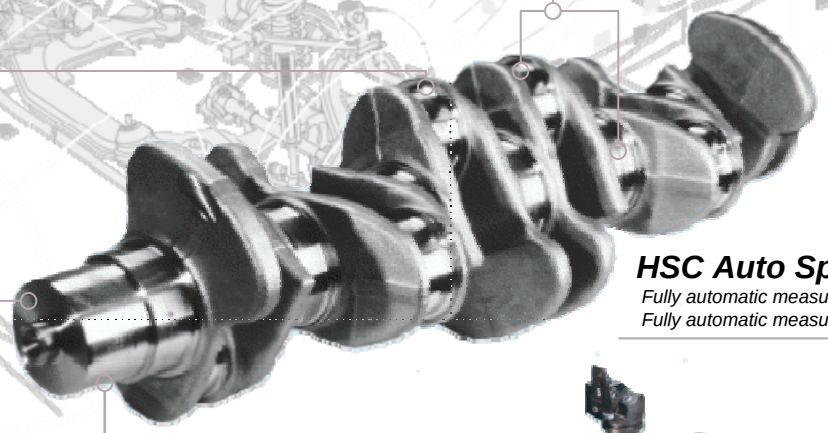
Turn Broaching Tool
for roughing and finishing
serveral crankshaft center
bearings simultaneously

Internal Mill Cutter
for roughing and finishing stroke bearings
for roughing and finishing center bearings

External Mill Cutter
for roughing and finishing stroke bearings
for roughing and finishing center bearings

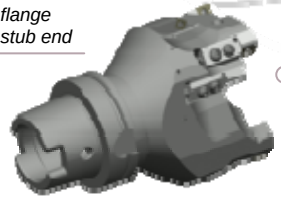
Turn-Turn Broaching Tool
for roughing and finishing center bearings

Dodeka / Octacut
for cutting crankshaft to length



HSC Auto Speed VME 195
Fully automatic measuring external mill cutters
Fully automatic measuring turn-turn broaching

„Hollow-Mill“-Cutter
Roughing flange
Roughing stub end



Turning Tools
for roughing and finishing flange
for roughing and finishing stub end

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300 Customers & 9000 proven Solutions

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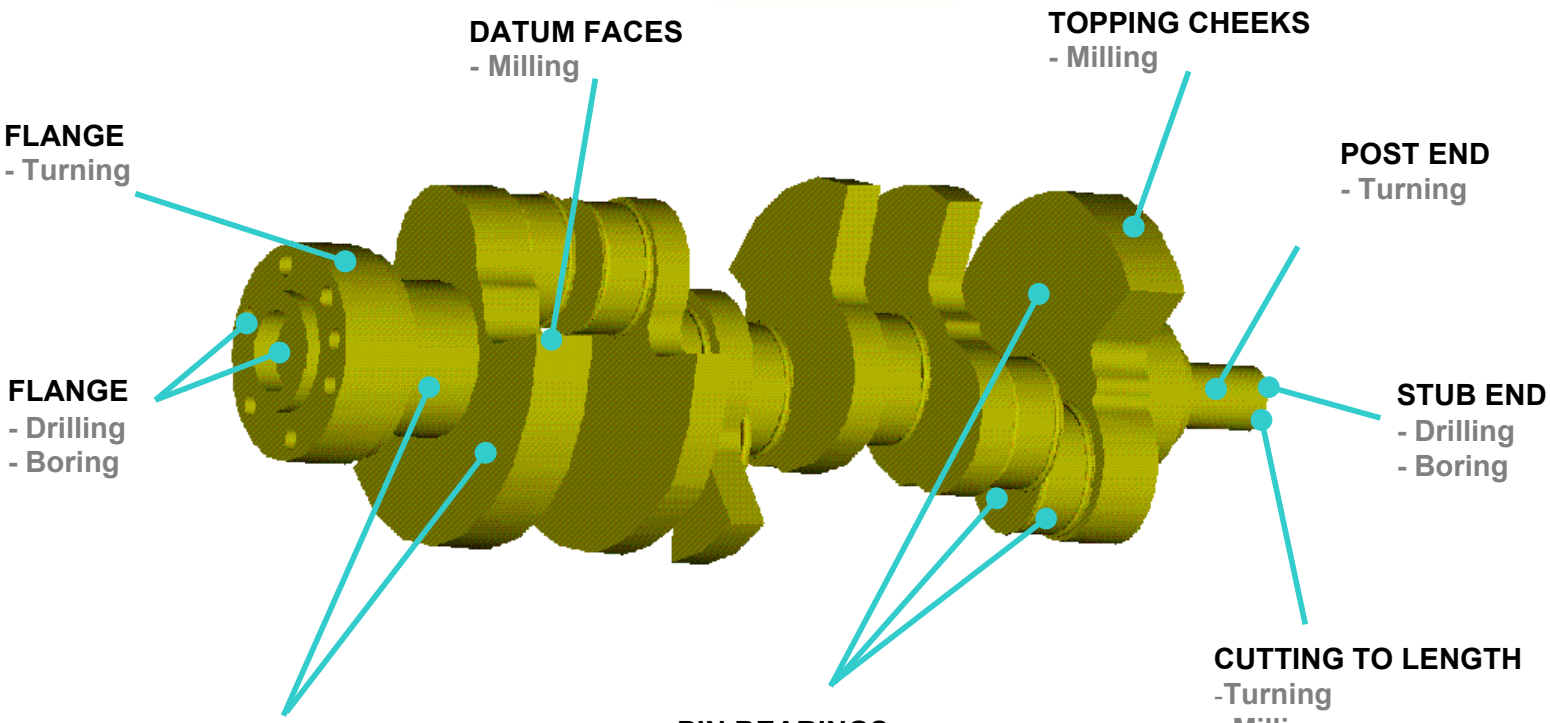
Crankshaft

Operations



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Proven Solutions for Engine Manufacturing

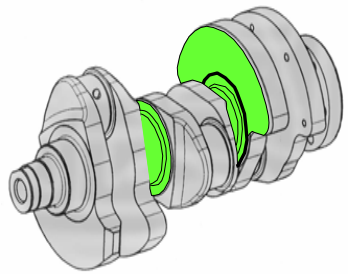
KENNAMETAL

Crankshaft Machining

Main Bearing Machining

Turn-Turnbroaching

Tool dia. ϕ : 700 ... 750 mm



Turn-Turnbroach
cartridge mounting

Roughing:
- cutting speed: 140 ... 200 m/min
- feed rate: 0,25 ... 0,5 mm^{-1}

Finishing:
- surface quality: R_z 4 ... 6 µm
- cutting speed: 160 ... 220 m/min
- feed rate: 1800 ... 2400 mm/min

Axial guidance
key / keyway

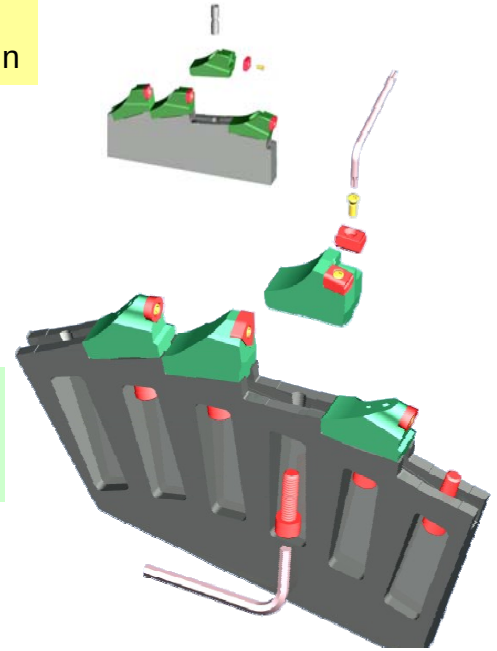
- ridgid and robust design
- high repeat accuracy
- small amount of spare parts

Radial mounting
socket cap screw

- easy to clean
- fast way to change cartridges
- standard screw

Tangential mounting
form fitted

- reliable force transmission



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Proven Solutions for Engine Manufacturing

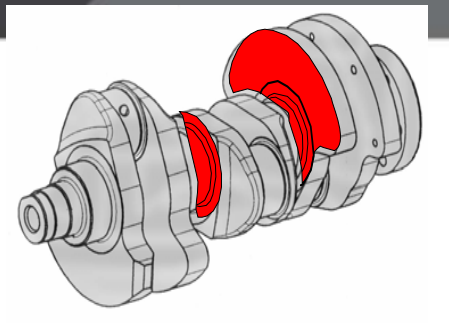
KENNAMETAL

Crankshaft Machining

External Milling

D = 700 ... 750

30 - 50 cartridges



External Milling
cartridge mounting

Axial guidance
positive stop

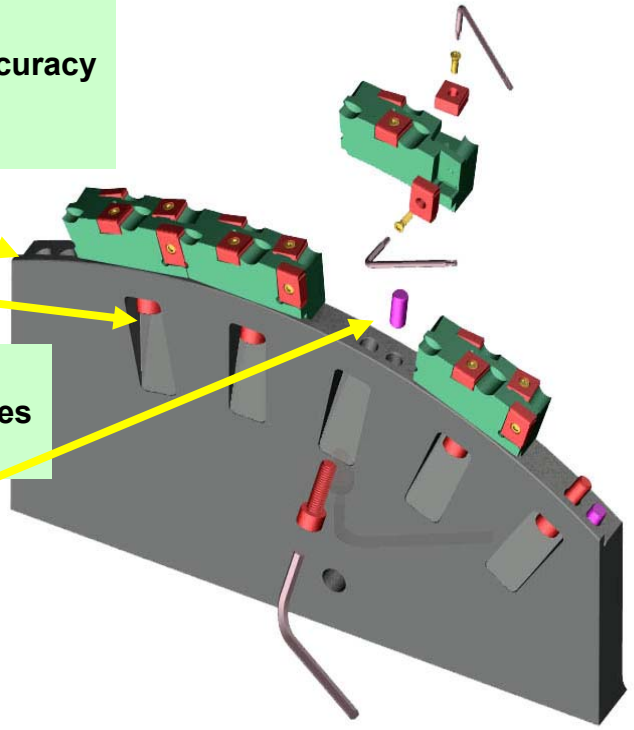
- ground surface
- high DO and Face run out accuracy
- highest repeatability
- small amount of spare parts

Radial mounting
socket cap screw

- easy to clean
- fast way to change cartridges
- standard screw

Tangential mounting
Pin

- reliable force transmission



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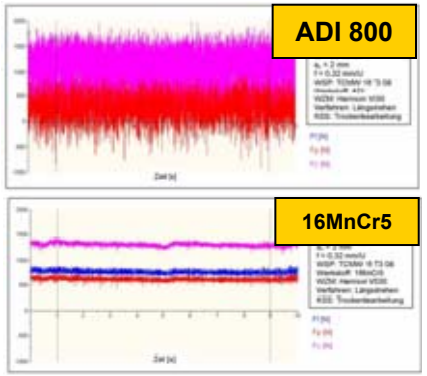
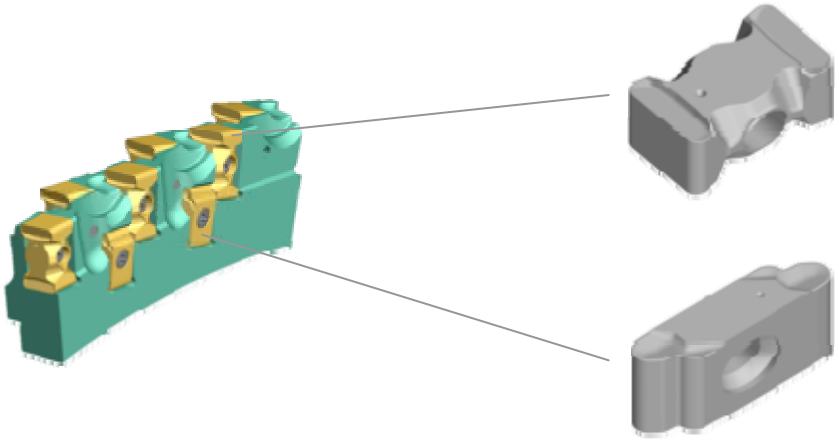
Crankshaft ADI Machining

Difficulty in machining ADI is due to high frequency large amplitude vibrations compared to nodular cast Iron and alloyed steels





- **Newly developed PVD coated Kennametal carbide grades closes the productivity gap for ADI milling & turning in comparison to Nodular Cast Iron**
- **For crankshaft insert machining Kennametal has developed new geometries and inserts to provide comparable maching performance to Nodular Cast Iron**
- **With the availability of new coated carbide grades with increased performance for ADI machining the share of ADI crankshafts will increase**

Proven Solution

Comparable lifetime for ADI & Nodular Cast iron tools achieved

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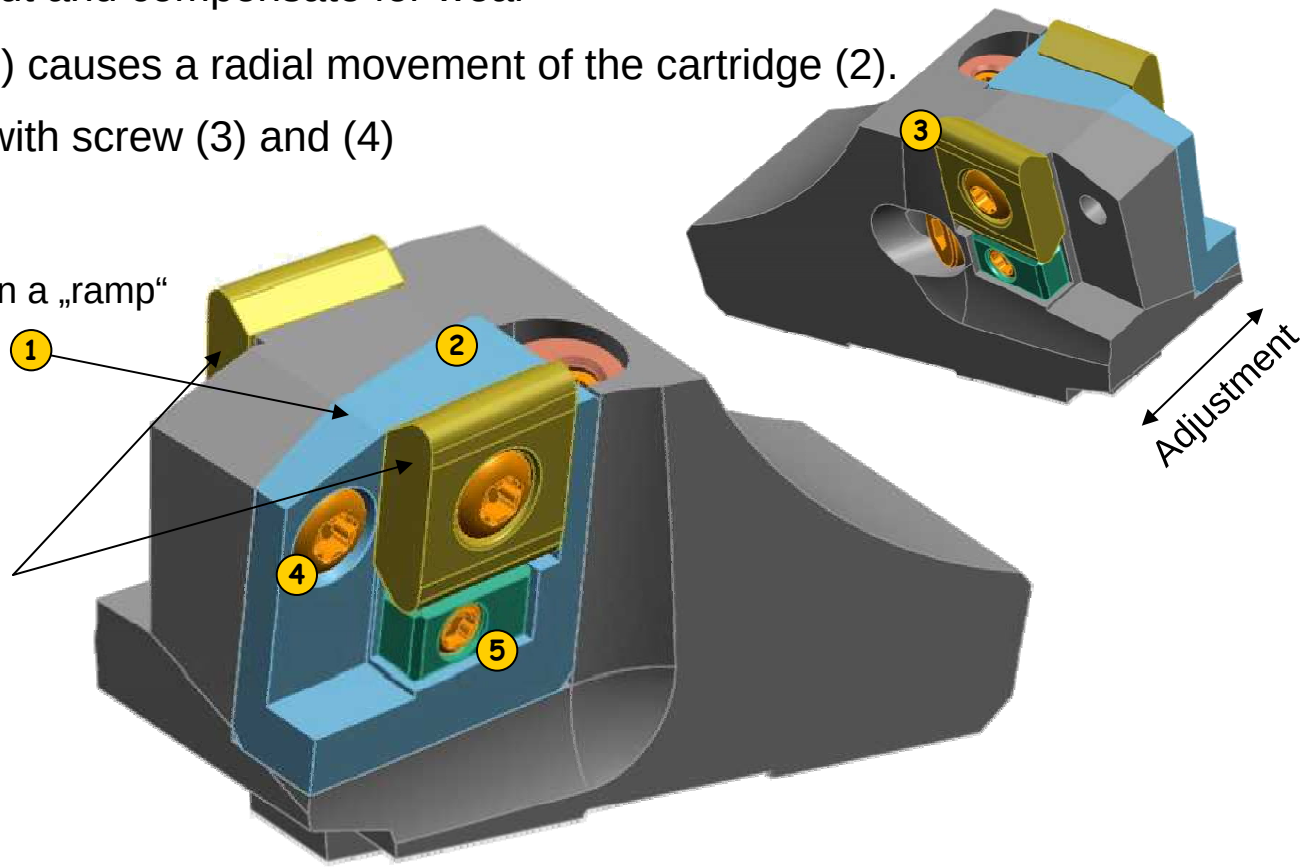
Crankshaft Process Adjustment

- Optimizing process adjustment
- Ability to change width of cut and compensate for wear
- Movement of the wedge (1) causes a radial movement of the cartridge (2).
- Clamping of the cartridge with screw (3) and (4)
- Carbide shim (5)

Movement of the insert on a „ramp“



Proven Solution

Process Compensation for Width and Wear

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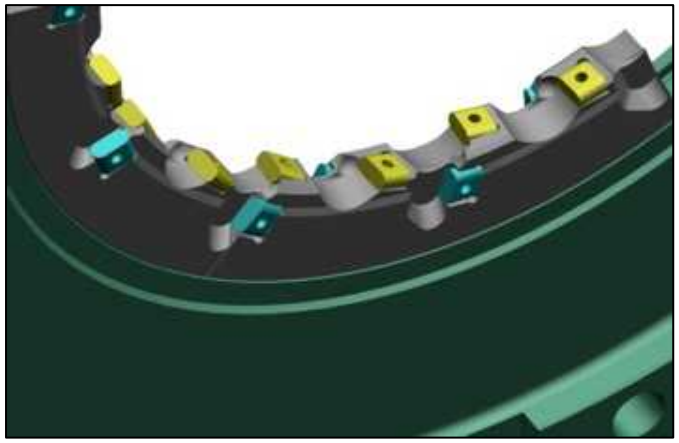
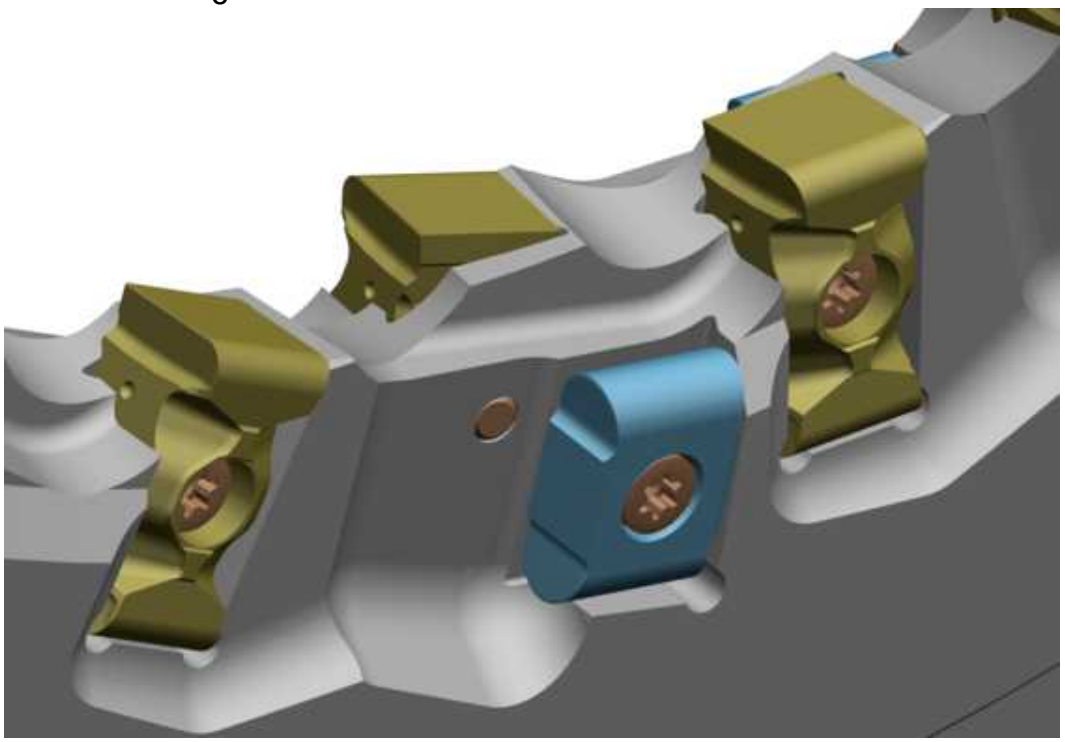
Crankshaft Insert Optimization

- Negative Cutting Geometry
- v_c : 120 - 160 m/min



Current Process

- Positive Cutting Geometry
- v_c = **240 m/min**



New Technology

Proven Solution

In Production in NA utilizing Heller machine

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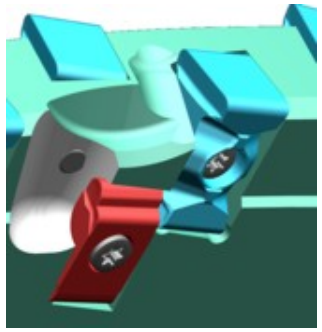
Crankshaft Disc Optimization

- Process optimization for internal and external milling
- Improved Cost through utilizing press technology
- Adjustability width of cut and run out quality
- Reduced setup times



CPP: **100%**

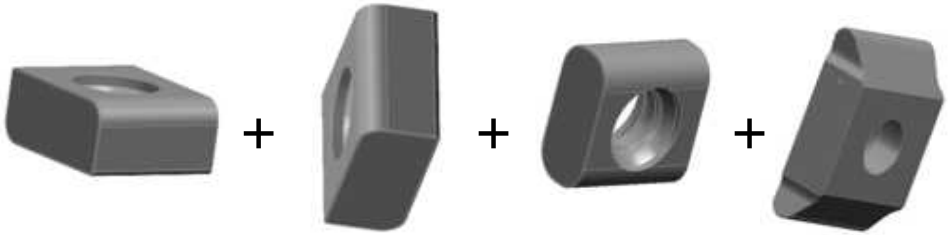
CPP: **69%**

Insert 1: 4 edges

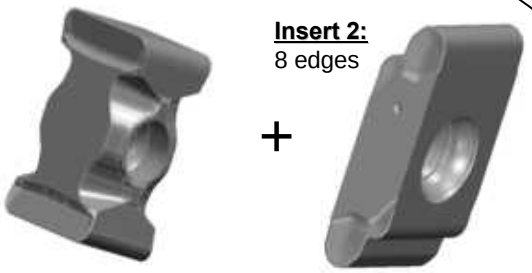
Insert 2: 4 edges

Insert 3: 8 edges

Insert 4: 4 edges



4 different Insert styles



Insert 2: 8 edges

Insert 1: 8 edges

2 different Insert styles

- Positive Cutting Geometry
- V_c = 240 m/min (From 120/160m/min)

Proven Solution

Consolidating Inserts and Improving Process Robustness

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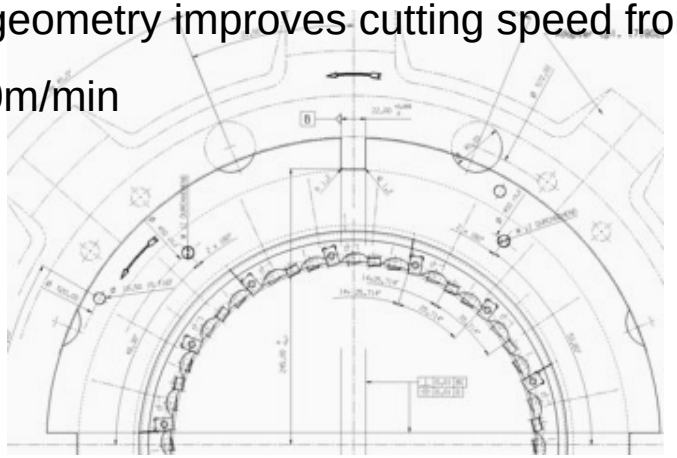
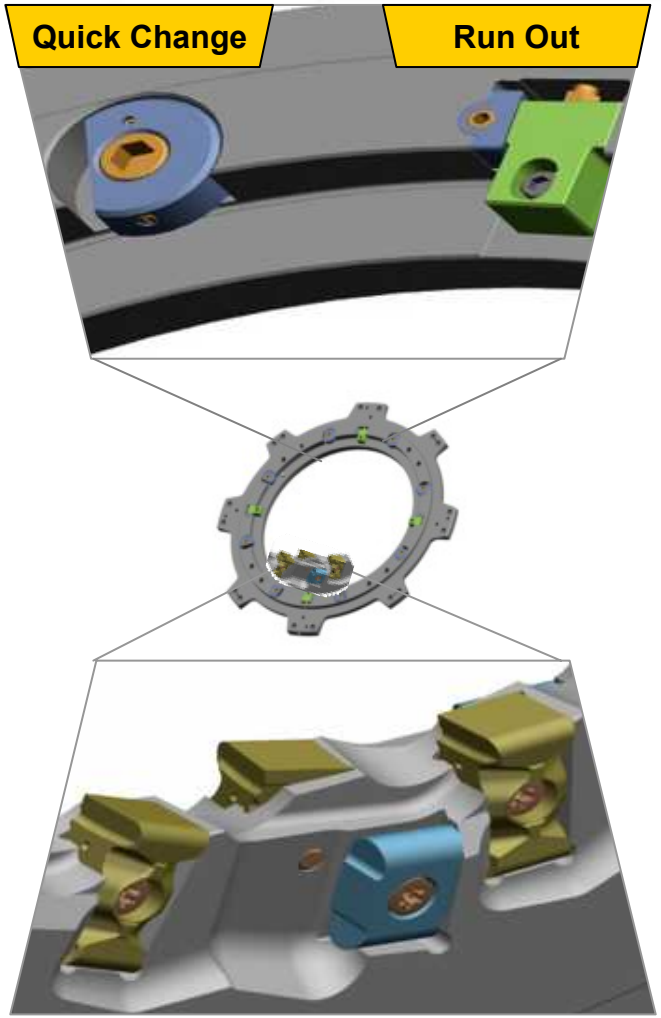
Crankshaft Internal Quick Tool

- Fast tool change developed to minimize downtime
- Improved run out adjustment allows segment construction
- Systems allows highest flexibility
- No crane needed
- Reduced Cost (Center disc one time purchase)
- Positive cutting geometry improves cutting speed from 160m/min to 240m/min





Proven Solution

1.1min per segment = 6.8min for total disc change

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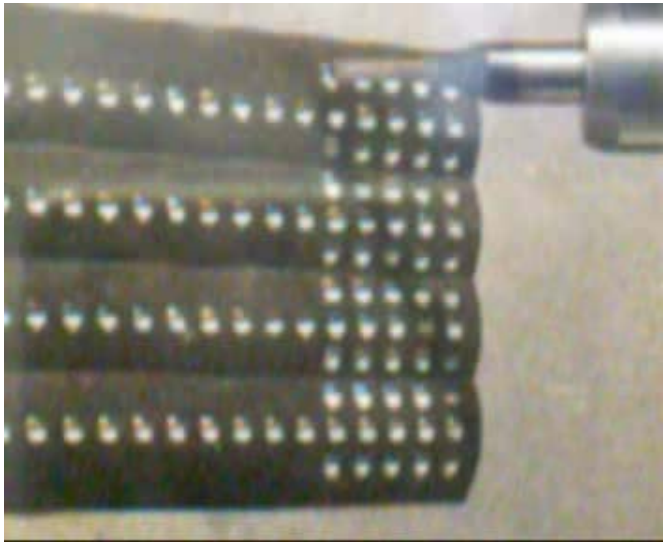
Crankshaft - Oil Hole Drilling

Solid Carbide – MQL Deep Hole Drilling



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MQL Deep Hole Drilling

Crankshaft Oil Holes

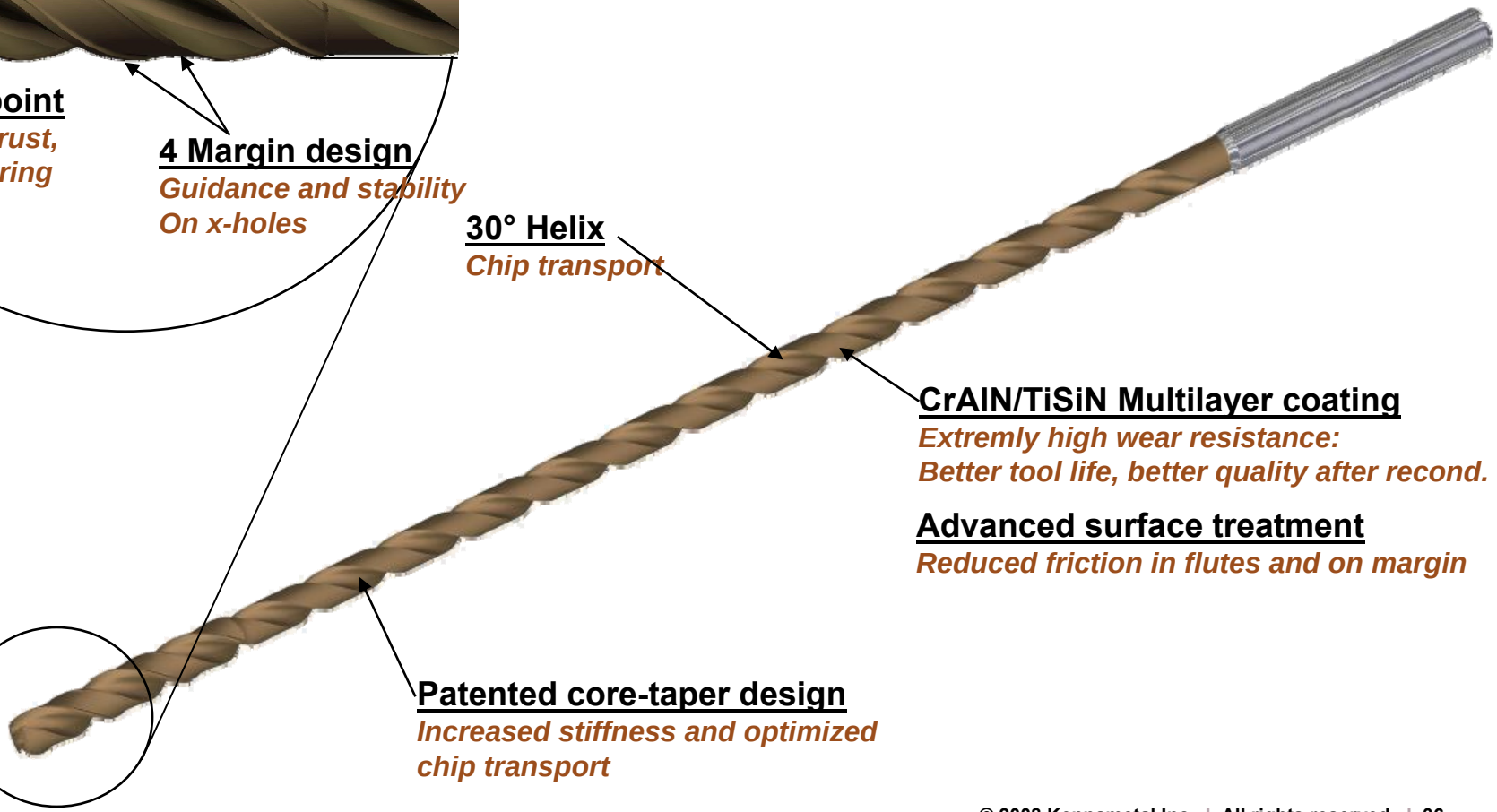
Diameter step on OD
Reduced contact with hole wall

135º HP point
Reduced thrust, Good centering

4 Margin design
Guidance and stability On x-holes

12.5% Co ultrafinegrain carbide
High chipping and fracture resistance

30° Helix
Chip transport



CrAlN/TiSiN Multilayer coating
Extremly high wear resistance: Better tool life, better quality after recond.

Advanced surface treatment
Reduced friction in flutes and on margin

Patented core-taper design
Increased stiffness and optimized chip transport

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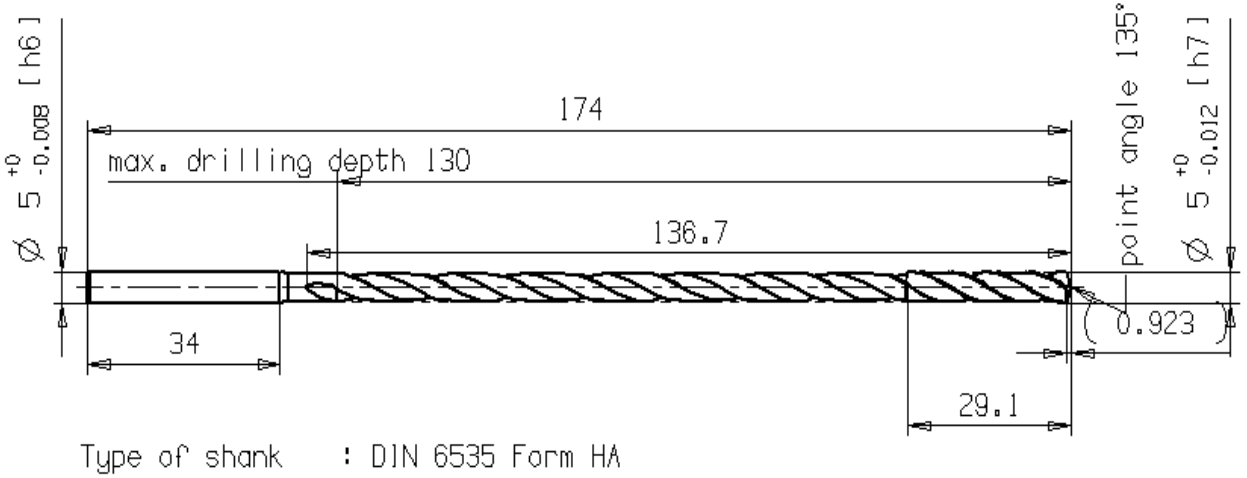
MQL Deep Hole Drilling

KENNAMETAL
Engineering Your Competitive Edge



Vc = 80 m/min

F = 0.3 mm/rev

Drilling Depth

25 x D

with

MQL

Tool life 100 m

Questions ?

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