Cutting Tool Solutions
For New Automotive Materials

Muneer Uddin
Global Automotive Portfolio Manager

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Measuring Engineering
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Kennametal Partners

Enhancing Partnerships Between OEM's & Suppliers

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CGI Block Portfolio

M680 Shoulder Mill Cutter
- Face & Shoulder milling
- Front / rear Side and eye area
- Cast iron and aluminium

M750 Hexacut
- Face mill cutter for roughing and finishing cast iron

Fix Perfect
- Face and corner mill cutter for roughing and finishing cast iron and aluminium

Cylinder Head Bore, Cast & Aluminium Liners
- Pre-machining with ceramic cutting material and carbide

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

Motion Tool
- Turning honing clearance

Octacut
- Side and face milling cutter for roughing cast iron and steel

Kamset Boring Head
- Semi- and finish machining of cylinder bore

Line Boring
- Semi- and finish machining of crankshaft bore

(Step) Drill
- Solid carbide and indexable insert drilling tools in hydraulic expansion chucks and heat shrink chucks
COMPACT GRAPHITE IRON
 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.

<table>
<thead>
<tr>
<th>Property</th>
<th>Gray Iron GG 35B</th>
<th>CGI GGV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hardness (Brinell)</td>
<td>160-235 HB</td>
<td>180-250 HB</td>
</tr>
<tr>
<td>Tensile Strength (MPa)</td>
<td>220-350</td>
<td>300-500</td>
</tr>
<tr>
<td>Elastic Modulus (GPa)</td>
<td>105</td>
<td>145</td>
</tr>
<tr>
<td>Fatigue Strength (MPa)</td>
<td>110</td>
<td>210</td>
</tr>
</tbody>
</table>
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
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
The Task:

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

The Data:

- \( v_c = 160 \text{ m/min} \)
- \( D = 78.5 \text{ mm}; \; z = 6 \)
- \( f_z = 0.2 \text{ mm/insert} \)
- \( v_f = 631 \text{ mm/min} \)

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 tool life (or 150min)
Cylinder Bore - Finishing on Machining Centers

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:

\[ v_c = 130 \text{ m/min} \]
\[ D = 80 \text{ mm} \]
\[ f_z = 0.25 \text{ mm/tooth; } z = 3 \]
\[ f = 300 \text{ mm/min} \]

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
CLB - Process Solution with Romicron

Romicron CLB - Process Summary

1st Step
- CLB Romicron Model (Pre-set at Presetter Machine)
- C-Axis Spindle
- Machine Table

2nd Step
- Part
- Measurement System

3rd Step
- Measurement Gauge
- Retractable Pin

4th Step
- Tool Adjustment
- Machine Table
- Finishing Hole

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

The Results:
- T = 900 blocks (1.800 faces) (breakouts)

The Data:
- D = 315 mm, zeff = 46
- vc = 100 m/min
- FPT = 0.25 mm
- DOC = 4 mm
M 750 - MCI Geometry

Geometry for roughing preferably at $\kappa_r = 45^\circ$
with $a_p = 3 - 4$ mm

Main features:
- Groove filled up in mid of edge
- Larger K-land in mid of edge
- 10 $\mu$m stronger honing

Benefit:
No notch wear
CGI - Milling Applications:

M750 with Bajonett Adapter:

Regular Design!
M750 with Bajonett Adapter:

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

Engine Block Machining

Aluminium
Bi-Metal
Face Mill M641 with Carbide Inserts

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 I4 blocks AlSi6 + GG26 (Spec)
Engine Block: Deck Face Grinding

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

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

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

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)

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

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

Kendex Precision Lock
Boring & Sinking, adjustable

PCD Monobloc
Boring & Sinking

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

Reamer
Camshaft bore Complete machining Of all journal bearings

TXD Drill PCD

TX Drill

TF Drill

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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

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

Transfer Line

Flexible CNC
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)

Combined tool systems – Reducing tools & Eliminating Changes
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

Combined tool systems – Reducing tools & Eliminating Changes
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.
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
Typical Bore Finishing Cost Savings

Semi Finish

<table>
<thead>
<tr>
<th>Detail</th>
<th>KMT</th>
<th>Competitor</th>
</tr>
</thead>
<tbody>
<tr>
<td>New Cost :</td>
<td>£3,000</td>
<td>£5,000</td>
</tr>
<tr>
<td>Refurb Cost :</td>
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<td>£3,000</td>
</tr>
<tr>
<td>Insert cost :</td>
<td>£195</td>
<td>£130</td>
</tr>
<tr>
<td>Insert cost / edge :</td>
<td>£49</td>
<td>£130</td>
</tr>
<tr>
<td>Insert Matl :</td>
<td>PCD</td>
<td>PCD</td>
</tr>
<tr>
<td>Inserts / Tool :</td>
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<td>1</td>
</tr>
<tr>
<td>Edges / insert :</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Compt / Edge :</td>
<td>40,000</td>
<td>35,000 - 40,000</td>
</tr>
<tr>
<td>Compt / Insert :</td>
<td>160,000</td>
<td>35,000 - 40,000</td>
</tr>
<tr>
<td>Speed r.p.m. :</td>
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<td>3500</td>
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<tr>
<td>Speed m/min :</td>
<td>270</td>
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</tr>
<tr>
<td>Feed mm/rev :</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>Feed mm/min :</td>
<td>350</td>
<td>350</td>
</tr>
</tbody>
</table>

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

Creating value through superior tools & process focus
Crankshafts Portfolio

300 Customers

Segment Solution - Roughing
- highest productivity
- best Flexibility

Segment Solution - Finishing
- highly adjustable to fulfill best runout

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

Turn Broaching Tool
- for roughing and finishing
  several 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

Dodeka / Octacut
- for cutting crankshaft to length

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

Segment Solution - Roughing
- highest productivity
- best Flexibility

Segment Solution - Finishing
- highly adjustable to fulfill best runout

Turn-Turn Broaching Tool
- for roughing and finishing center bearings

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

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

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300 Customers & 9000 proven Solutions
Crankshaft

Operations

- DATUM FACES - Milling
- TOPPING CHEEKS - Milling
- POST END - Turning
- STUB END - Drilling - Boring
- FLANGE - Turning
- FLANGE - Drilling - Boring
- MAIN BEARINGS - Roughing and Semifinishing - With / Without cheeking
- PIN BEARINGS - Roughing and Semifinishing - With / Without splitpin - With / Without cheeking
- CUTTING TO LENGTH - Turning - Milling
Crankshaft Machining
Main Bearing Machining

**Turn-Turnbroaching**

*Tool dia. $\phi$ : 700 ... 750 mm*

**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
Crankshaft Machining

External Milling

*D = 700 ... 750
*30 - 50 cartridges

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
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 machining 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.

Comparable lifetime for ADI & Nodular Cast iron tools achieved.
• 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“
Crankshaft Insert Optimization

- Negative Cutting Geometry
  - \( v_c \) : 120 - 160 m/min

- Positive Cutting Geometry
  - \( v_c = 240 \) m/min

Current Process

New Technology

In Production in NA utilizing Heller machine
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

Positive Cutting Geometry

- \( V_c = 240 \text{ m/min} \) (From 120/160m/min)

Consolidating Inserts and Improving Process Robustness
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

1.1min per segment = 6.8min for total disc change
Crankshaft - Oil Hole Drilling

Solid Carbide – MQL Deep Hole Drilling
CrAlN/TiSiN Multilayer coating
Extremely 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
12.5% Co ultrafinegrain carbide
High chipping and fracture resistance
Crankshaft Oil Holes
Diameter step on OD
Reduced contact with hole wall
135° HP point
Reduced thrust, Good centering
4 Margin design
Guidance and stability On x-holes
30° Helix
Chip transport
CrAlN/TiSiN Multilayer coating
Extremely high wear resistance:
Better tool life, better quality after recond.
Advanced surface treatment
Reduced friction in flutes and on margin
MQL Deep Hole Drilling

Vc = 80 m/min
F = 0.3 mm/rev

Drilling Depth
25 x D

Type of shank: DIN 6535 Form HA

Tool life 100 m

with MQL