SOLUTIONS FOR COMPOSITE
High strength carbon fiber is widely used in the aeronautic and automobile industries, as well as in wheelchairs, F1 chassis, bicycle frames and wind power generation blades for light structures that require strength. However, the life of such tools is extremely short due to the high strength. In addition, it is effective to use tools with a high abrasion resistance coating in composite material machining where delamination and burr is liable to occur during cutting due to the laminate structure.

**AEROSPACE**

Structural component

Wing

Fuselage

Engine case

**Drilling**

The CVD diamond coating and cemented carbide drill equipped with an edge shape optimized by application and high abrasion resistance provide stability that minimizes burr and delamination.
automobile industries, as well as in wheelchairs, F1 chassis, structures that require strength. However, the life of such tools is extremely short due to the high strength. In addition, it is effective to use tools with a high abrasion resistance coating in composite material machining where delamination and burr is liable to occur during cutting due to the laminate structure.

**Trimming**

The end mill that combines an optimized edge shape and high wear resistance CVD diamond coating maintains high quality.
## DRILLING TOOLS

### DRILL

<table>
<thead>
<tr>
<th>Material</th>
<th>Description</th>
<th>Tools</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CFRP</strong></td>
<td>Standalone CFRP</td>
<td>MCC (DD2105)</td>
</tr>
<tr>
<td><strong>CFRTP</strong></td>
<td>For CFRP/CFRTP</td>
<td>MCAH (DT2030)</td>
</tr>
<tr>
<td><strong>CFRP/Al Stack Materials</strong></td>
<td>For CFRP/CFRTP</td>
<td>MCW (DD2110)</td>
</tr>
<tr>
<td><strong>CFRP/Ti Stack Materials</strong></td>
<td>For CFRP/CFRTP</td>
<td>MCT (TF15)</td>
</tr>
</tbody>
</table>

**MCC**
- The cutting edge angle = 90° setting minimizes cutting resistance in the thrust direction. This controls delamination and maintains good hole quality.

**MCA**
- The groove design that wraps up chips also minimizes gaps of CFRP and aluminum hole diameter in addition to preventing contact between the chips and the CFRP hole wall surface.

**MCW**
- The unique cutting edge shape with V-shaped grooves on the cutting edge controls the flow of chips generated at the outer circumference. Furthermore, this minimizes the hole diameter gaps in stack materials. Burr on the hole exit side is controlled by shifting the cutting load to the rotating shaft.

**MCT**
- The sharp cutting edge in titanium machining which requires good CFRP hole quality and machining that minimizes the generation of cutting heat with low thermal conductivity achieves high-quality CFRP and titanium stack material hole machining.

**Hand Tool**
- Hand Tool (Standalone CFRP) | MCCH (DT2030) |
- Hand Tool (CFRP/Al Stack Materials and High Precision Holes) | MCW (DD2110) |
- Hand Tool (CFRP/Ti Stack Materials and High Precision Holes) | MCW (DD2110) |

*CFRTP = Carbon Fiber Reinforced Thermoplastic Resin*
END MILLS

Four Flutes

*DFC4JC*

The low resistance cutting edge with low helix angle reduces delamination and burrs when machining CFRP.

Performance

*DFCJRT*

The cross-nick type cutting edge allows high efficiency machining due to lower cutting resistance and reduced temperatures.

Features

Proprietary CVD diamond coating

The newly developed CVD diamond coated carbide material achieves outstanding abrasion resistance and smoothness due to a proprietary fine multilayer diamond crystal control technology.
**DRILLING TOOLS**

**MCC**

90° Cutting Edge Angle
The acute cutting angle thoroughly reduces thrust and minimizes delamination.

Strong Rake Grooves
The cutting edge rake angle has been strengthened in the vertical direction on the axis of rotation. As a result, it is possible to minimize un-cutting and delamination on sharp cutting edges.

**Comparison of Tool Life and Hole (Entrance/Exit)**

<table>
<thead>
<tr>
<th>MCC A</th>
<th>MCC B</th>
<th>Conventional</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Bar Chart" /></td>
<td><img src="image2" alt="Bar Chart" /></td>
<td><img src="image3" alt="Bar Chart" /></td>
</tr>
</tbody>
</table>

*The tool life determination depends on the chipping*

- **MCC A**
- **MCC B**
- Conventional

**Cutting condition**

- Tool: ø6.55
- Work material: CFRP(0)
- Cutting speed: 120m/min
- Feed: 0.10mm/rev
- Cutting mode: Dry cutting

**After 820 holes machining**

- Can continue

---

**Table:**

<table>
<thead>
<tr>
<th></th>
<th>306 holes</th>
<th>588 holes</th>
<th>MCC (1192 holes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Entrance</td>
<td><img src="image4" alt="Image" /></td>
<td><img src="image5" alt="Image" /></td>
<td><img src="image6" alt="Image" /></td>
</tr>
<tr>
<td>Exit</td>
<td><img src="image7" alt="Image" /></td>
<td><img src="image8" alt="Image" /></td>
<td><img src="image9" alt="Image" /></td>
</tr>
</tbody>
</table>
New Groove Structure

The groove design that covers up chips also minimizes back counter in addition to minimizing contact between the chips and the CFRP hole wall surface.

TRI-Cooling® Technology

Controlling the cutting heat reduces deterioration of the CFRP hole precision caused by heat (improves the internal air effectiveness).

Groove Shape Effect

Conventional

FAQ

Back Counter Occurrence

Outside the hole tolerance standards (6 holes)

*Hatching: Required hole precision

<Cutting condition>

Tool: 2510° (ø6.38)

Work material: CF (11mm) + Al (5mm)

CF Cutting speed: 100 m/min
Feed: 0.15 mm/rev

Al Cutting speed: 100 m/min
Feed: 0.15 mm/rev
Cutting mode: Internal air
### DRILLING TOOLS

**MCC**

**Standalone CNC / CFRP**

---

#### RECOMMENDED CUTTING CONDITIONS

<table>
<thead>
<tr>
<th>Work Material</th>
<th>CFRP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dia. DC (inch)</td>
<td>Dia. DC (mm)</td>
</tr>
<tr>
<td>---------------</td>
<td>-------------</td>
</tr>
<tr>
<td>.1875</td>
<td>4.76</td>
</tr>
<tr>
<td>.251</td>
<td>6.38</td>
</tr>
<tr>
<td>.3125</td>
<td>7.96</td>
</tr>
<tr>
<td>.375</td>
<td>9.55</td>
</tr>
<tr>
<td>.4375</td>
<td>11.14</td>
</tr>
</tbody>
</table>

---

* : Inventory maintained in Japan. (Available Spring 2017)  □ : Non stock, produced to order only. (Available Spring 2017)
### DRILLING TOOLS

#### MCA

**CNC / CFRP + Al**

<table>
<thead>
<tr>
<th>Hole Dia.</th>
<th>Drill Dia.</th>
<th>Grade</th>
<th>Dimensions (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AWG * inch</td>
<td>DC (mm)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1/4</td>
<td>6.38</td>
<td>.251</td>
<td>MCA0638X05S070</td>
</tr>
<tr>
<td>3/8</td>
<td>9.55</td>
<td>.375</td>
<td>MCA0955X05S100</td>
</tr>
</tbody>
</table>

**RECOMMENDED CUTTING CONDITIONS**

<table>
<thead>
<tr>
<th>Dia. DC (inch)</th>
<th>Dia. DC (mm)</th>
<th>Cutting speed (m/min)</th>
<th>Revolution (min⁻¹)</th>
<th>Feed (Min.—Max.) (mm/rev)</th>
<th>Feed rate (mm/min)</th>
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</tr>
</thead>
<tbody>
<tr>
<td>.251</td>
<td>6.38</td>
<td>100</td>
<td>5000</td>
<td>0.15 (0.10—0.20)</td>
<td>750</td>
<td>100</td>
<td>5000</td>
<td>0.03 (0.02—0.04)</td>
<td>150</td>
<td></td>
</tr>
<tr>
<td>.375</td>
<td>9.55</td>
<td>100</td>
<td>3400</td>
<td>0.15 (0.10—0.20)</td>
<td>680</td>
<td>100</td>
<td>3400</td>
<td>0.03 (0.02—0.04)</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

### MCT

**CNC / CFRP + Ti**

<table>
<thead>
<tr>
<th>Hole Dia.</th>
<th>Drill Dia.</th>
<th>Grade</th>
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<td>15</td>
<td>750</td>
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<td>1</td>
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<td>3400</td>
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<td>680</td>
<td>15</td>
<td>500</td>
<td>0.02 (0.01—0.03)</td>
<td>10</td>
<td>1</td>
</tr>
</tbody>
</table>

1) This condition is for when internal air or mist is used.

*: Inventory maintained in Japan. (Available Spring 2017) □: Non stock, produced to order only. (Available Spring 2017)
**DRILLING TOOLS**

**MCW**

Standalone CNC / CFRP and stack material high precision

---

**RECOMMENDED CUTTING CONDITIONS**

**Work Material**

<table>
<thead>
<tr>
<th>Dia. DC (inch)</th>
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<td>680</td>
</tr>
</tbody>
</table>

1) This condition is for when internal air or mist is used.
2) We recommend the same cutting conditions even in the case of dry machining.

---

**Peck Machining Method (Applicable for MCT and MCW)**

Set the machining start position to 3 mm above normal.

Refer to the recommended conditions for CFRP. Machine the cutting edge of the drill to at least 1 mm (0.040") before the metal.

Peck machine 3 mm (0.115") for aluminum and 1 mm (0.040") for titanium for the metal machining area.

Set it so that it returns to its start position during peck machining.

---

* AWG : American Wire Gage

---

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Set it so that it returns to its start position during peck machining.
### MCCH

**Hand tool / standalone CFRP**

<table>
<thead>
<tr>
<th>Hole Dia.</th>
<th>Drill Dia.</th>
<th>Order Number</th>
<th>Grade</th>
<th>Dimensions (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AWG * inch</td>
<td>DC (mm) inch</td>
<td></td>
<td>DCON</td>
<td></td>
</tr>
<tr>
<td>#40</td>
<td>2.5</td>
<td>.0985</td>
<td>MCCH0250X15S030</td>
<td>★</td>
</tr>
<tr>
<td>#30</td>
<td>3.26</td>
<td>.1285</td>
<td>MCCH0326X15S040</td>
<td>★</td>
</tr>
<tr>
<td>#20</td>
<td>4.1</td>
<td>.1615</td>
<td>MCCH0410X10S050</td>
<td>★</td>
</tr>
<tr>
<td>#11</td>
<td>4.86</td>
<td>.1915</td>
<td>MCCH0486X10S050</td>
<td>★</td>
</tr>
<tr>
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<td>6.38</td>
<td>.251</td>
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<td>★</td>
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<td>.375</td>
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<td>★</td>
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* AWG : American Wire Gage

### MCAH

**Hand tool / CFRP + Al**

<table>
<thead>
<tr>
<th>Hole Dia.</th>
<th>Drill Dia.</th>
<th>Order Number</th>
<th>Grade</th>
<th>Dimensions (mm)</th>
</tr>
</thead>
<tbody>
<tr>
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<td>DC (mm) inch</td>
<td></td>
<td>DCON</td>
<td></td>
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SOLUTIONS FOR COMPOSITE

DRILLING TOOLS

Request sizes other than those in the inventory by inserting the code and numerical value in the □ of the following model numbers. Contact our sales department for details on the dimensions.

Order number

MC □ □ □ □ X□ D □ □

Hole Depth (l/d)
Size range: 2-5

Shank Dia. DCON
Size range: 030-200

Drill Dia. DC
Size range: 0300-2000

*Minimum diameter with internal coolant is φ4mm (0.1575”).

Applications
C: Standalone CNC / CFRP
A: CNC / CFRP + Al
T: CNC / CFRP + Ti
W: Standalone CNC / CFRP and stack material high precision
CH: Hand tool / standalone CFRP
AH: Hand tool / CFRP + Al

Work material

Type
• CFRP: Thermosetting and thermoplasticity
• Type of reinforcing fiber
• Metal: Aluminum or titanium, etc.

Combination
• Standalone CFRP or CFRTP
• CFRP + stack materials (aluminum or titanium)
• Lap joint method

Other
• Thickness for each work material
• Affixure of film

Equipment

Type
• CNC
• Hand Tool
• Power feeders etc.

Coolant
• Internal through
• Air, MQL and dry, etc.

Hole Quality
• Required hole diameter (upper and lower limit of tolerance)
• Surface roughness of the hole inner wall
• Metal burr height
• CFRP and metal hole diameter gap

Size range of drill dia.: φ3mm-φ20mm
Size range of shank dia.: φ3mm-φ20mm
For cutting dia DC - Please indicate with 4 digits
E.g. φ3mm - 0300
For shank dia DCON - Please use 3 digits
E.g. φ12mm - 120
*For inch sizes please convert to metric
(1” = 25.4mm)
CVD diamond coating with outstanding abrasion resistance and superior sharpness for high quality CFRP machining.

DFC Series
CVD diamond coated end mill for CFRP machining

Geometry for CFRP machining

DFC4JC
For finishing

DFCJRT
For efficient machining

The low resistance cutting edge with low helix angle reduces delamination and burrs when machining CFRP.

The cross-nick type cutting edge allows high efficiency machining due to lower cutting resistance and reduced temperatures.

Long tool life

<table>
<thead>
<tr>
<th>Cutting length (m)</th>
<th>DFC4JC</th>
<th>Conventional</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.3</td>
<td>0.3</td>
</tr>
<tr>
<td>5</td>
<td>0.2</td>
<td>0.2</td>
</tr>
<tr>
<td>10</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>15</td>
<td>0.0</td>
<td>0.0</td>
</tr>
</tbody>
</table>

Excellent surface finish

Less burrs

Cutting direction

Conventional

Burrs

Cutting direction

Cutting direction

DFC4JC

End mill
DFC4JCD1000 (ø10)

Work material
CFRP
(Thick: 5.3mm)

Revolution
6400min⁻¹
(200m/min)

Feed rate
800mm/min
(0.03mm/tooth)

Coolant mode
Air blow

End mill
DFC4JCD1000 (ø10)

Work material
CFRP
(Thick: 6mm)

Revolution
6000min⁻¹
(188m/min)

Feed rate
750mm/min
(0.03mm/tooth)

Coolant mode
Air blow
MILLING TOOLS

DFC4JC

End mill, Semi long cut length, 4 flute, for CFRP

RECOMMENDED CUTTING CONDITIONS

<table>
<thead>
<tr>
<th>Work material</th>
<th>Dia. (mm)</th>
<th>Revolution (min⁻¹)</th>
<th>Feed rate (mm/min)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>6</td>
<td>11000</td>
<td>950</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>8000</td>
<td>780</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>6400</td>
<td>700</td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>5300</td>
<td>650</td>
</tr>
</tbody>
</table>

1) Cutting conditions may differ considerably due to the kind of CFRP, the rigidity of the machine, or the clamping and geometry of the workpiece. Please use the left table as a standard starting point.
2) When high machining accuracy is needed, or large burrs or delamination occurs, we recommend reducing the feed rate.
3) When the depth of cut is greater than 0.8DC, we recommend reducing the feed rate.
4) Please take precautions against dust.

Please contact Mitsubishi Materials for geometries and through coolant types other than standard.

Order Number | DC | APMX | LF | DCON | N | Stock | Type |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>DFC4JCD0600</td>
<td>6</td>
<td>20</td>
<td>70</td>
<td>6</td>
<td>4</td>
<td>★</td>
<td>1</td>
</tr>
<tr>
<td>DFC4JCD0800</td>
<td>8</td>
<td>30</td>
<td>80</td>
<td>8</td>
<td>4</td>
<td>★</td>
<td>1</td>
</tr>
<tr>
<td>DFC4JCD1000</td>
<td>10</td>
<td>30</td>
<td>90</td>
<td>10</td>
<td>4</td>
<td>★</td>
<td>1</td>
</tr>
<tr>
<td>DFC4JCD1200</td>
<td>12</td>
<td>30</td>
<td>100</td>
<td>12</td>
<td>4</td>
<td>★</td>
<td>1</td>
</tr>
</tbody>
</table>
Cross-nick type end mill, Semi long cut length, for CFRP

Please contact Mitsubishi Materials for geometries and through coolant types other than standard.

RECOMMENDED CUTTING CONDITIONS

<table>
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<tr>
<th>Work material</th>
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<th>Dia. (mm)</th>
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<th>Feed rate (mm/min)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>6</td>
<td>11000</td>
<td>1200</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8</td>
<td>8000</td>
<td>1000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10</td>
<td>6400</td>
<td>900</td>
</tr>
<tr>
<td></td>
<td></td>
<td>12</td>
<td>5300</td>
<td>850</td>
</tr>
</tbody>
</table>

1) Cutting conditions may differ considerably due to the kind of CFRP, the rigidity of the machine, or the clamping and geometry of the workpiece. Please use the left table as a standard starting point.
2) When high machining accuracy is needed, or large burrs or delamination occurs, we recommend reducing the feed rate.
3) When the depth of cut is greater than 0.8DC, we recommend reducing the feed rate.
4) Please take precautions against dust.

Recommended Tools According to Type of CFRP

<table>
<thead>
<tr>
<th>Type</th>
<th>Surface and inside: Cloth material</th>
<th>Surface → Cloth material Inside → Uni-direction material</th>
<th>Surface → Glass fiber material Inside → Uni-direction material</th>
</tr>
</thead>
<tbody>
<tr>
<td>DFC4JC</td>
<td>☀</td>
<td>☀</td>
<td>☀</td>
</tr>
<tr>
<td>DFCJRT</td>
<td>☀</td>
<td>☀</td>
<td>☀</td>
</tr>
</tbody>
</table>

Burr
Liable to occur

: Inventory maintained in Japan. ★ : Inventory maintained in Japan. (Available Spring 2017)