Mobile and stationary ULTRASONIC-machining of COMPOSITES for MRO and Production.
Perfect edge trimming for series production; accurate scarfing and surface cleaning for MRO.

Mobile and stationary ULTRASONIC-machining

1. Production

- Trimming and drilling of CFRP / GFRP / AFRP components for series production
  - Highlights
    - Trimming with optimum surface quality without chipping or chatter marks for the subsequent joining processes
    - Drilling holes e.g. rivet holes with the best possible roughness values in the channel, diameter tolerances in the μm-range and reduced outbreaks on the initial drilling surface as well as the through-pierce side
    - Feasibility of through drilling holes and tapped blind holes, threads, grooves, pockets and other geometric free forms
    - Machining in a full section without fibre tearing or delamination

- Stationary 5-axis Machining
  - Long-term stable machine concepts
  - High-performance exhaust system
  - Surface measurement through integrated laser scan
  - Surface cleaning through integrated atmospheric pressure plasma

- Technology Benefits
  - 40% reduced process force: prevention of built-up edges
  - Double feeds due to ULTRASONIC
  - Excellent component quality without delamination

- Mobile 5-axis Milling Unit
  - Universal use for production and MRO
  - Highest precision and reproducibility
  - Lightweight construction with CFRP components

2. Maintenance, Repair & Overhaul (MRO)

- Scarfing by accurately exposing the individual laminate layers
  - Highlights
    - Scarfing in a full section without fibre tearing or delamination
    - Reverse engineering: Integrated laser scanner for surface recognition, feedback and re-measuring
    - Integrated atmospheric pressure plasma: Surface activation/cleaning for optimal preparation for the subsequent reconstruction processes
    - Stationary and mobile
Efficient machining of high-end components made of fibre-reinforced composite materials (e.g. CFRP, GFRP, AFRP) as well as fibre-reinforced ceramics with ULTRASONIC.

Holistic solutions for Production and MRO

Fibre composites are ideally suited for the production of lightweight components due to their high strength and minimal weight. The use of CFRP and GFRP in civil aviation continues to grow and all premium manufacturers in the automotive industry produce important structural components out of fibre reinforced plastics. Even in the field of wind energy, all aerodynamic components today are made of composite materials.

In addition to the actual production applications, there is also an ever-growing demand for automated, economical machining options for maintenance, repair and overhaul (MRO) of damaged fibre composite components. In both fields, the use of ULTRASONIC technology along with SAUER’s comprehensive process approach, offers a breakthrough solution for a most efficient machining of these high-performance materials with optimal component quality.

DMG MORI offers the mobile as well as the stationary processing solution for both categories – Production and MRO.

Primary Target Markets

Aerospace
Automotive
Renewable Energies
Ship Building
Lifestyle

Rotor Blade Segment / CFRP
Centre Console / CFRP
Scarfing in airfoil
Adaption on car roof
Rotor Cover / CFRP
Dashboard Panel / CFRP
Repair of a damaged rotor blade
Milling of the bull-eye
Watch Housing / CFRP
Efficient ULTRASONIC-machining of high-end components made from COMPOSITES.

Into the future with ULTRASONIC

Common machining methods for fibre composite raw parts have technical shortcomings, caused by high tool wear, inadequate component quality and usable feed limitations. This is precisely where DMG MORI can help you to reach the next level, with the ULTRASONIC technology.

The defined superimposition of the tool rotation with an ULTRASONIC oscillation in the longitudinal direction leads to a significant reduction of the process forces, an increase of tool life as well as an optimized chip breakage and removal. This way, ULTRASONIC allows to cut the material fibres with an increased cutting speed and therewith meets the requirements of productivity and workpiece quality. The reduction of the process forces by up to 40% enables clean edges and prevents fibre tearing and delamination on the part.

Due to the optimisation of the mechanical machine components as well as the integration of application-specific technologies (e.g. surface detection / feedback by laser, surface cleaning / activation by atmospheric pressure plasma), mobile and stationary machining solutions are developed that are specialized for the series production of COMPOSITE-components as well as for the repair of damaged surfaces in the MRO sector.

Prevent built-up edges through optimal tool design and ULTRASONIC

In close partnership with the leading tool manufacturers in this field of application, carbide tools were optimally developed for ULTRASONIC machining with special cutting geometries.

Sharp edges and prevention of fibre tearing with ULTRASONIC

Process forces are significantly reduced through the use of ULTRASONIC technology, enabling high edge quality without process-induced thermal damage, fibre tearing or delamination.

ULTRASONIC Benefits

- Up to 40% reduced process forces to prevent delamination and fibre tearing
- Double feeds possible through ULTRASONIC
- Longer tool life by preventing built-up edges
- Optimal particle removal from the active zone
- Excellent component quality: Sharp edges, clean exposure of the individual laminate layers, perfect surfaces

Operating Principle

The conventional rotation of the tool is superimposed (piezoelectric effect) via the HSK / A63 interface of the ULTRASONIC actuator recording with an additional oscillation in the axial direction.
Stationary high-performance ULTRASONIC-machining of fibre composites with holistic machine concept.

### Technical Data

<table>
<thead>
<tr>
<th>Machine Design</th>
<th>ULTRASONIC 85</th>
<th>ULTRASONIC 260</th>
<th>ULTRASONIC 360</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
<td>monoBLOCK®</td>
<td>Travelling Column</td>
<td>Travelling Column</td>
</tr>
<tr>
<td>Travel (mm)</td>
<td>850 / 850 / 650</td>
<td>2,600 / 700 / 700*</td>
<td>3,600 / 1,100 / 900</td>
</tr>
<tr>
<td>Max. Speed (Standard / Option) (rpm)</td>
<td>18,000 (24,000)**</td>
<td>18,000** (24,000 / 35,000)**</td>
<td>18,000** (24,000 / 35,000)**</td>
</tr>
<tr>
<td>Tool Holder (Standard / Option)</td>
<td>HSK-A63</td>
<td>HSK-A63</td>
<td>HSK-A63</td>
</tr>
<tr>
<td>Max. Workpiece Dimensions (mm)</td>
<td>700 × 700 × 500</td>
<td>2,000 × 650 × 550****</td>
<td>3,000 × 1,050 × 750</td>
</tr>
<tr>
<td>Max. Load (3-axis / 5-axis) (kg)</td>
<td>1,500</td>
<td>2,150 / 500*****</td>
<td>5,000 / 1,200</td>
</tr>
</tbody>
</table>

* Machine version 260|11 with travel in Y (1,100 mm), Z (900 mm)
** Max. speed ULTRASONIC: 18,000 rpm
*** 35,000 rpm spindle only available for version with HSK-E50
**** Machine version 260|11 with 2,000 × 1,000 × 700 mm
***** Machine version 260|11 with 4,000 / 1,200 kg
Mobile 5-axis milling unit for MRO as well as demanding production tasks.

Small, light, mobile – with highest performance

Repair jobs of damaged fibre composite components are up to now mainly performed as manual operations by hand. In most cases, e.g. the aircraft has to be brought back to the hangar which requires a few days of repair time. In contrast to this time-consuming procedure, the new mobile 5-axis milling unit from DMG MORI enables to handle the actual repair jobs in only a few minutes, with 100 % constant quality, precision and reproducibility. The 5-axis kinematics with integrated rotary- and swivel-axis allows challenging operations with angles of a 95°. Due to the lightweight construction and the specially designed vacuum system, the ULTRASONIC mobileBLOCK can be adapted easily and flexible onto the damaged components. Additionally to the repair jobs in the MRO sector, this mobile milling unit can also be effectively integrated in the process chain of challenging production tasks.

Technical Data ULTRASONIC mobileBLOCK

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Travel X / Y / Z mm</td>
<td>500 / 500 / 200</td>
</tr>
<tr>
<td>Max. Speed rpm</td>
<td>35,000</td>
</tr>
<tr>
<td>Tool holder DIN ER11</td>
<td></td>
</tr>
<tr>
<td>Swivel range (A-axis) degree</td>
<td>± 95°</td>
</tr>
<tr>
<td>Swivel range (C-axis) degree</td>
<td>360° (infinite)</td>
</tr>
<tr>
<td>Rapid traverse m/min</td>
<td>14</td>
</tr>
<tr>
<td>Dimensions mm</td>
<td>1,300 x 1,300 x 1,000</td>
</tr>
<tr>
<td>Weight kg</td>
<td>aprr. 85 kg</td>
</tr>
<tr>
<td>Adaption system</td>
<td>SAUER 12 / 16</td>
</tr>
<tr>
<td>Suction power N</td>
<td>256 (per foot)</td>
</tr>
</tbody>
</table>

Kinematics

- Powerful kinematic machine layout with X-, Y-, Z-, C-, A-axis
- 5-axis simultaneous machining
- High performance spindle with 35,000 rpm, with a 200 mm measuring range of a 2-axis spindle made from CFRP
- C-axis: 250 mm travel
- Highest dynamics due to optimised spindle

Lightweight Design

- Selected materials for weight optimisation: 80% CFRP, 15% aluminium, 5% tool steel
- Frame, cover of servo motors, A axil and adaption arms made from CFRP
- Use of CFRP for reduced thermal expansion
- Increased damping factors
- Increased handling and flexible adaption

Control Design

- Easy, PC-based control with 21" Touchscreen
- Highly dynamic due to homogenous control according to the part drawing. In the definition of the damaged area and repair jobs, the laser surface detection, up to the generation of the final NC-files
- Internet access

Integrated Laser Scan

- Two different laser types: Point- and line-scanner
- Optimised for CFRP operations
- Point laser scanner for detection of the workpiece surface up to 2,000 mm measuring range
- Line laser scanner with up to 400 single points for surface feedback of 3D forms
- Easy assembly / disassembly in a few seconds

Highly dynamic Servo Motors

- Acceleration up to 7 m/s² possible
- Max. rapid traverse of 14 m/min
- High dynamics due to homogenous control
- High torque in the rotary axes
- All servo motors with direct drives (Excite motors)
- Homogenous and aligned drive design for highest efficiency

Powerful Adaption

- Double angle compensation possible due to adjustable adaption arms and vacuum feet with ball joint
- Easy assembly / disassembly of vacuum feet
- Max. adaption range: 800 mm
- Easy 50 % of the vacuum feet are mandatory for adaption

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Lightweight design with flexible adaption possibilities.

**Adaption example // AEROSPACE**

The flexibly adjustable vacuum feet of the ULTRASONIC mobileBLOCK generate a vacuum power of 256 N per foot. 12 vacuum feet are in the standard – 16 pc. are available optionally. Flexible ball joints allow an easy and quick adaption not only on flat surfaces (e.g. airfoil) but especially on components with radii and complex contours (e.g. frame elements of the aircraft fuselage).

**Concept study // Automated repair solution**

In the standard, a quick adaption of the ULTRASONIC mobileBLOCK is possible via crane. Therewith, this mobile milling unit can be docked flexibly to various surface contours. The concept study below shows a possible scenario for an automated positioning of the ULTRASONIC mobileBLOCK by a mobile transport colly on tires or rails – for the universal and automated adaption for MRO as well as production tasks.

**Stationary as well as mobile repair solution with holistic process-know-how.**

**Repair steps**

1. Deassembly or positioning of the damaged component
2. Defining the machining strategy, incl. generation of the NC path (approx. 15 min)
3. Surface cleaning (approx. 1 min)
4. Scarfing of the component
5. Surface activation / cleaning
6. Reconstruction

**Stationary**

- Deassembly or positioning of the damaged component
- Defining the machining strategy, incl. generation of the NC path (approx. 15 min)
- Surface cleaning (approx. 1 min)
- Scarfing of the component
- Surface activation / cleaning
- Reconstruction

**Mobil**

- Deassembly or positioning of the damaged component
- Defining the machining strategy, incl. generation of the NC path (approx. 15 min)
- Surface cleaning (approx. 1 min)
- Scarfing of the component
- Surface activation / cleaning
- Reconstruction
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