Friction Stir Welding
Equipment and Technology portfolio
The Friction Stir Welding (FSW) technology by Grenzebach enables the joining of technically pure metals, alloys and mixed material compounds while providing a solid bond of exceptional quality.

Grenzebach, as an experienced system integrator and supplier of friction stir welding equipment, delivers turnkey FSW process solutions for industrial serial production.

Apart from supplying welding machinery and equipment, Grenzebach’s integrated approach also includes process development for a customer’s various applications as well as providing customized FSW tools. FSW tools, like friction pins and shoulders, are designed and manufactured in house according to specific customer requirements (e.g. welding speed or durability of the tools). This integrated approach ensures that the welding equipment, process parameters and welding tools perfectly match and contribute to the highest joint quality.

Furthermore, Grenzebach provides assistance starting with the design phase of the customer’s product for appropriate part joint design and materials selection. Test welding, prototyping and small batch contract manufacturing are available using Grenzebach’s in-house FSW machines and robot cells at any time.

**APPLICATION INDUSTRIES**
- Automotive
- Energy transmission / Power electronics
- Battery production
- Rail vehicle manufacturing
- Aerospace technology
- Consumer electronics
- and many more...

During the FSW process a rotating, wear-resistant welding tool generates frictional heat at the welding zone. The material becomes malleable and is stirred along the welding path by the welding tool without reaching the melting temperature of the joining materials. The stirred material is compacted by the tool shoulder and a solid, media and pressure-tight joint between the work pieces is formed.

Compared to conventional fusion welding processes (e.g. arc welding), FSW does not require additional welding wire, inert gas or complex exhaust systems. Furthermore, FSW does not generate any discernible noise, emissions or optical radiation.

**HIGHLIGHTS**
- Solid phase joining technology, i.e. the process temperature is below the melting point of the materials
- Durable media and pressure-tight welding seams
- Joining of aluminium alloys that are not or hardly fusion-weldable
- Particularly suitable for the joining of mixed compounds with different alloys and metals as well as different product forms (e.g. wrought alloys with aluminium die cast)
- No formation of hydrogen pores or hot cracking
- Highly reproducible seam strength and seam quality
- No auxiliaries, such as inert gas, powder, welding wire etc. required
- No significant impact on the work environment due to dust, gases, smoke, radiation etc.
GRENZEBACH DynaSTIR – an advancement of the FSW tool technology

DynaSTIR Friction Stir Welding technology

HIGHLIGHTS
- High quality seam surface (usually no refinish required)
- Significantly reduced process forces compared to the conventional tooling
- Highly dynamic welding enabled by non-rotating tool shoulder
- Separate parameterization of the friction pin and the tool shoulder are possible to realise an end-hole closure
- The shoulder geometry can be adapted to the joint geometry, e.g. shoulder for fillet weld, Tailored-Blanks etc.
- Reduced heat input
- Enables the application of the process for joining of thin sheets with material thicknesses < 1.0 mm
- Independant replacement of friction pin and shoulder possible

We asked ourselves how a good process can be improved even more. With the DynaSTIR tool technology we were able to accomplish just that. In particular. The welding tool is separated in two components (i.e. pin and shoulder) and the tool shoulder travels along the welding seam without any rotation. The results of the numerous installations speak for themselves.

Whether DynaSTIR or a conventional FSW technology, decisive for the welding seam and the surface quality is the control of the process parameters. Chief among them is the pressure force, which is high-dynamically reported back to the machine and process control via the sensor technology of the welding head and forms together with the individual axes of the lead machine the force control circuit.

There is even another feature for the DynaSTIR technology: Different weld depths on a component can be realized with just one FSW tool type enabled by dynamic adjustments of the weld depth. If necessary, also a reduction of the end hole can be achieved.

HIGHLIGHTS
- Rotational speed up to 8000 rpm
- Force-controlled process via high precision sensors
- Integrated tilt axis of 0 - 5°
- Chuck for the DynaSTIR technology
- Pneumatic tool chucking for high-speed tool change
- Variable setting of the welding depth
(Optional for the DynaSTIR technology)
Dynamic Stirring Machine (DSM) – 100% designed for welding
Innovative equipment technology for the perfect welding result.

The compact 4-axis gantry machines of the DSM series were developed specially to meet the requirements of the FSW process. The focus during the development of these machines was geared towards dynamic and precise process control as well as an intuitive control and operating concept.

**HIGHLIGHTS**

**HYDROPOL® machine bed** – Specially designed for very high static rigidity, low dynamic flexibility and deformation in steel-covered polymer concrete.

**4-axes gantry system** – Designed for high axis dynamics and precise line guidance. The integrated C-axis allows the welding head to rotate by +/-720° and enables much higher process dynamics for joining complex path trajectories with narrow radii.

- Gantry traversing speed: up to 13 m/min
- Welding speed: up to 3 m/min
- Working ranges: DSM1400 1400 x 1000 x 400 mm
  DSM2400 1400 x 2400 x 400 mm
  further dimension upon request
- Max. axial force (gantry): 8000 N
- Accuracy (in the process): +/-0.1 mm

**Machine and process control** – With the IndraMotion MTX control by Bosch Rexroth, Grenzebach relies on well proven CNC control technology and combines this with innovative FSW process control. The machine and process programming is made easier via FSW CAD/CAM programming software.

**Ergonomics & Operation comfort**

The pivoting control panel with a 21 inch touch panel allows the operator to keep an eye on all welding parameters and machine data at a glance. A handheld controller is provided to manually control the axes.

The large window in the front allows maximum visibility into the work space for the best supervision of the welding process. Optionally, it is possible to follow the welding process at the control panel via a camera integrated into the welding head.

Heavy assemblies and devices can be moved easily in and out of the machine with the help of an indoor crane. The machine is open at the top and the protective door at the front of the machine is sufficiently large to ensure accessibility to the entire working area.

At the back of the machine, the service and maintenance personnel have easy access to the control hardware and the central power supply.

**Additional options**

- Automated friction pin length measurement
- Configurable, automated tool changing station for quick tool change
- Sensors for calibrating fixtures and components
- Media supply for DSM shuttle systems (pneumatic, hydraulic, electric)
Double spindle FSW machines of the D-DSM series

Further productivity boost from Grenzebach

Due to the addition of a second gantry to the DSM two independently working welding heads are available for the welding operation. The immediate use? A reduction of the effective cycle time!

But that’s not all! Especially in the case of high production volumes, this leads to economic potentials, which are directly addressed with the D-DSM series. Therefore the efficiency boost of the overall invest can be reduced significantly with a reduction of system and equipment demands.

D-DSM2400 Double spindle equipment

- Independently operating welding heads for reduction of the effective cycle time
- Workpiece supply system from both sides for cycle time concurrent loading and unloading
- The usual low-level heat input due to the DynaSTIR technology

Workpiece supply systems for enhanced productivity

In terms of cycle time, the rapid loading and unloading of workpieces is just as important as the dynamics and speed of the welding machine.

Modular, expandable, automatic feeding systems for simultaneous welding and loading / unloading of work pieces outside of the machine. The loading and unloading of components can be done manually by the operator with the help of a manipulator or an indoor crane, or fully automated.

HIGHLIGHTS

Frontal DSM feeding system

- Moveable workpiece-/device carrier system (linear guide system) for loading and unloading work pieces simultaneous to welding
- Two separate moveable pallets (work tables) with a working area of each 630 x 500 mm (DSM1400)
- T-groove system (option)

Lateral DSM feeding system

- One or two moveable workpiece-/device carrier systems, the last ones for simultaneous loading and unloading of components
- Two separate, moveable pallets (work tables) with a working area of
  - 1 400 x 1 000 mm (DSM1400)
  - 1 400 x 2 400 mm (DSM2400)
- others on request
- T-groove system
DSM Turnkey full automation

Scalable solutions for serial production

Pictures say more than 1 000 words and if you are interested in details, click on the video link below. Scan the following QR code and let us convince you of our scalable turn-key solutions on our YouTube channel. https://www.youtube.com/watch?v=Krkys-7eEEs

HIGHLIGHTS
– Integration into a higher level line control system or MES
– Material transport with Automated Guided Vehicles from Grenzebach
– Scalable for variable production volumes
– Remote maintenance access and On-Site support

6-axes-FSW robot systems of the DSR series

Dynamic Stirring Robot (DSR) – the welding all-rounder

The robot-based FSW systems from Grenzebach are characterized by their flexibility, as well as the possibility to realize difficult 3D welding curves.

HIGHLIGHTS

Designed for high flexibility and maximum degrees of freedom.
– Welding speed: up to 2 m/min
– Working range DSR2000:
  - R=1295 mm – 2675 mm (X/Y level) Z=3371 mm
– Max. axial force: 8000 N
– Max. radial force: 5000 N
– Max. welding head rotation speed: 6000 rpm
– Accuracy (in the process): +/- 1 mm

Development systems
R&D robot cells from Grenzebach are ideal for Research & Development projects. These cells can be combined with any additional equipment, such as welding tables, measuring equipment or media supply for the highest flexibility.

Robot-based turn-key solutions for flexible production
Good clamping devices and half the welding work is already done! For this purpose, Grenzebach optionally offers a clamping device developed especially for your products to achieve an ideal welding result. This and further features, such as an advance process development or an on-site installation ensure a real turn-key solution for your production.
In addition to programming of the welding path and the FSW-process parameters, control of clamping fixtures and components can subsequently be programmed in the CAD/CAM environment. Programming is done offline on a separate PC which prevents blocking the system. The finished welding program can then be easily entered into the DynaSTIR machine control system through a USB or network connection.

**HIGHLIGHTS**
- Import of 3-D models
- Select the geometry, define the course of the weld path in the 3-D model
- Easy modification possibilities for the path geometry (move path points and segments and interpolation of transitions)
- Determination of the FSW process parameters and changes for individual path points and segments
- Insertion of action points into the weld path (e.g. for the control of clamping elements [up to 64] or sensor queries)
- Collision warning for tools and components
- Reachability check (i.e. can the kinematics basically reach the line)
- Possibility to import different friction tool geometries.
- Creation and administration of a tool data base
- Documentation function / traceability of parameter or weld path changes

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**FSW process consulting, development and prototyping**
- Application consulting
- Feasibility studies
- Test and experimental welds
- Process development and optimization
- Design and fabrication of customized friction tools
- Design and manufacturing of component specific welding fixtures
- Sample and prototype welding
- Pre-series production
- Production ramp-up support

**Courses & Trainings**
- FSW process basics
- CAD/CAM path and process programming
- Metallography
- System operator training
- Service & Maintenance

**After Sales Services**
- 24/7 Hotline
- Remote support
- Preventive maintenance
- On-site service interventions
- FSW tool and spare parts service
- Customized service contracts
- Warranty prolongation

**Destructive and Non-Destructive Tests**
- Welding test methods (e.g. visual check and penetration test)
- Tensile and bending tests
- Geometric part measurement (CMM)
- Seam surface analysis
- Macro section tests incl. evaluation
- Hardness measurements (Vickers/Brinell)

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**Service Portfolio**

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**FSW CAD/CAM Professional**

**Independent from the equipment type you decide to go with: It's only a few clicks from the 3D model to the finished welding program.** The programming software developed especially for the friction stir welding processes enables the user to create a welding program.

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### Technical data

#### DSM1400, DSM2400 & D-DSM FSW machine

<table>
<thead>
<tr>
<th>DSM1400</th>
<th>DSM2400</th>
<th>D-DSM</th>
<th>DSR2000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of axes</td>
<td>4 (X, Y, Z, C)</td>
<td>4 (X, Y, Z, C)</td>
<td>4 (X, Y, Z, C)</td>
</tr>
<tr>
<td>Work area (axes)</td>
<td>X 1 400 mm, Y 1 200 mm, Z 400 mm, C +/-720°</td>
<td>X 1 400 mm, Y 2 400 mm, Z 400 mm, C +/-720°</td>
<td>X 1 400 mm, Y 2 400 mm, Z 400 mm, C +/-720°</td>
</tr>
<tr>
<td>Door size / loading options</td>
<td>Door width: 1 400 mm / Crane/robot loading</td>
<td>Door width: 1 400 mm / Crane/robot loading</td>
<td>Door width: 1 400 mm / Crane/robot loading</td>
</tr>
<tr>
<td>Max. force (gantry)</td>
<td>8 kN (DynaSTIR), 10 kN (Conventional)</td>
<td>8 kN (DynaSTIR), 10 kN (Conventional)</td>
<td>8 kN (DynaSTIR)</td>
</tr>
<tr>
<td>Max. advance high speed (gantry)</td>
<td>15 m/min</td>
<td>15 m/min</td>
<td>15 m/min</td>
</tr>
<tr>
<td>Max. interpolation speed</td>
<td>5 m/min</td>
<td>5 m/min</td>
<td>5 m/min</td>
</tr>
<tr>
<td>Accuracies (over all process axes)</td>
<td>+/-0.1 mm</td>
<td>+/-0.1 mm</td>
<td>+/-0.1 mm</td>
</tr>
<tr>
<td>Dimensions L, W, H</td>
<td>L 3 500 mm, W 5 400 mm, H 5 600 mm</td>
<td>L 5 500 mm, W 4 800 mm, H 5 600 mm</td>
<td>L 5 500 mm, W 5 600 mm, H 5 600 mm</td>
</tr>
<tr>
<td>Machine bed</td>
<td>In steel-surrounded polymer concrete design HYDROPOL®</td>
<td>In steel-surrounded polymer concrete design HYDROPOL®</td>
<td>In steel-surrounded polymer concrete design HYDROPOL®</td>
</tr>
<tr>
<td>Weight</td>
<td>14 t</td>
<td>18 t</td>
<td>24 t</td>
</tr>
<tr>
<td>Compressed air</td>
<td>5 bar</td>
<td>5 bar</td>
<td>5 bar</td>
</tr>
<tr>
<td>Voltage supply</td>
<td>400 V / 50 Hz</td>
<td>400 V / 50 Hz</td>
<td>400 V / 50 Hz</td>
</tr>
<tr>
<td>Average power requirement</td>
<td>8.25 kVA</td>
<td>8.25 kVA</td>
<td>8.25 kVA each spindle</td>
</tr>
<tr>
<td>Control system</td>
<td>Bosch Rexroth IndraMotion MTX</td>
<td>Bosch Rexroth IndraMotion MTX</td>
<td>Bosch Rexroth IndraMotion MTX</td>
</tr>
<tr>
<td>Operation</td>
<td>21” Touch Panel</td>
<td>21” Touch Panel</td>
<td>21” Touch Panel</td>
</tr>
<tr>
<td>Handheld keypad</td>
<td>Euchner HM-112392 with electronic handwheel</td>
<td>Euchner HM-112392 mit elektronischem Handrad</td>
<td>Euchner HM-112392 mit elektronischem Handrad</td>
</tr>
</tbody>
</table>

#### DSM component supply systems

### Frontal DSM feeding systems

<table>
<thead>
<tr>
<th>DSM1400</th>
</tr>
</thead>
<tbody>
<tr>
<td>Working range of the supply system</td>
</tr>
<tr>
<td>Media supply</td>
</tr>
<tr>
<td>Accommodation system for devices (option)</td>
</tr>
<tr>
<td>Max. loading</td>
</tr>
</tbody>
</table>

### Lateral DSM feeding systems

<table>
<thead>
<tr>
<th>DSM1400</th>
<th>DSM2400</th>
</tr>
</thead>
<tbody>
<tr>
<td>Working range of the supply system</td>
<td>X 1 400 mm, Y 1 000 mm, Z 400 mm</td>
</tr>
<tr>
<td>Media supply</td>
<td>Hydraulics, Pneumatics, Electrics</td>
</tr>
<tr>
<td>Accommodation system for devices (option)</td>
<td>T-grooves</td>
</tr>
<tr>
<td>Max. loading</td>
<td>1 000 kg</td>
</tr>
</tbody>
</table>

### Further variants upon request

- Frontal DSM feeding systems
- Lateral DSM feeding systems

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### Technical data

#### DSR2000 FSW robot

- Number of axes: 6
- Work area (axes): X 1 295 mm – 2 675 mm (X/Y-level), Z 2 571 mm
- Door size / loading options: Cell-dependent
- Max. force (gantry): 10 kN (DynaSTIR)
- Max. advance high speed (gantry): 2 m/min
- Max. interpolation speed: 2 m/min
- Accuracies (over all process axes): +/-0.1 mm
- Dimensions L, W, H: L 5 045 mm, W 2 000 mm, H 5 602 mm
- Machine bed: MobileCell robot platform (steel building scaffold)
- Weight: 8.5 t
- Compressed air: 5 bar
- Voltage supply: 400 V / 230 V / 50 Hz
- Average power requirement: 7.5 – 10 kVA
- Control system: Grenzebach/KUKA KRC4
- Operation: Touch Panel
- Handheld keypad: Euchner HM-112392 with electronic handwheel

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### Further variants upon request

- Frontal DSM feeding systems
- Lateral DSM feeding systems

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