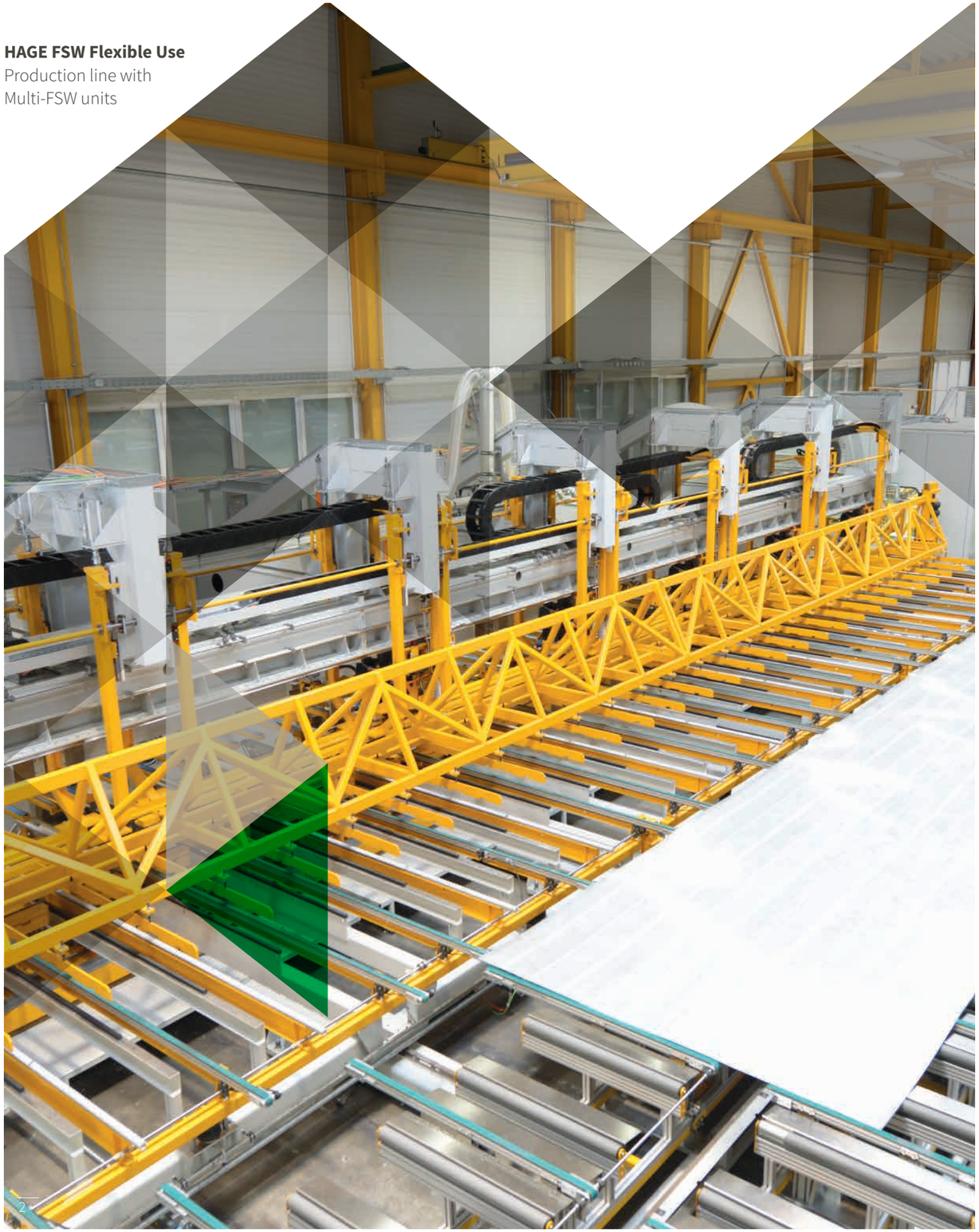
INNOVATIVE FSW SOLUTION

HAGE



HAGE FSW Flexible Use
Production line with
Multi-FSW units

HAGE YOUR AUTOMATIC ADVANTAGE

AUTOMOTIVE
AUTOMATION

FSW COMPETENCE CENTER
TAILOR-MADE COMPLETE SOLUTIONS

FAMILY-RUN COMPANY
SPECIAL MACHINE CONSTRUCTION

MULTI-AXIS GANTRY PROCESSING SYSTEMS

AEROSPACE TECHNOLOGY

35 YEARS' EXPERIENCE

INDUSTRIAL PLANT ENGINEERING

MADE IN AUSTRIA
INTERNATIONAL REFERENCES

QUALITY YOU CAN TRUST
INNOVATION LEADER

RAILWAY INDUSTRY

FRICTION STIR WELDING

- High welding speeds
- Fully automatic process monitoring and control
- High joint strengths
- High reproducibility
- Almost no welding distortion thanks to lower heat input
- No filler metals
- No shielding gas
- Simple process
- Mixed joints possible

Friction stir welding is a technology that uses frictional heating to soften the pieces of material being joined in such a way that they merge without melting into a liquid state. Two workpieces are butted together and then a hard, rotating tool with a special tip profile – with a pin and a shoulder – is pressed into the joint and travels along its length. The heat produced under the shoulder of the tool lowers the flow stress, and plasticizes the material without reaching the melting point. A flow zone forms around the tool, and friction within the material generates additional heat. The material flows around the rotating pin and becomes consolidated into a homogeneous mass, forming a strong joint on cooling. FSW is a technique without filler metals.

A key factor: the joint must be firmly supported from the rear to withstand the forces applied by the tool.

Micrograph of the weld joint

Progression of the pressure force and the position of the tool in the phases of the FSW welding process.

FRICTION STIR WELDING

THE SOLID PHASE JOINING METHOD OF THE FUTURE

FSW is an excellent, fully process-compatible welding technology for lightweight fabrication in railway industry, aircraft, spacecraft, automotive, shipbuilding and in industrial plant. In order to achieve perfect conditions for the FSW process, HAGE has developed an extremely rigid machine platform that can be adapted to meet individual customer needs – for example in the popular and trusted HAGE FSW series.

THE HAGE FSW PROCESS

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HAGE

CONSULTING

- Years of experience
- Solutions tailored to customer-specific requirements:
  - Highly rigid machine concept
  - Optimum workpiece geometries
  - Appropriate clamping concept
  - Determination of process parameters and times
- FSW Standard DIN EN ISO 25239 - Part 1–5

PRELIMINARY TESTING

- Preliminary testing in the HAGE Competence Center
- Position- and force-controlled welding tests
- Geometrical testing
- Process and parameter studies
- Development of clamping concepts
- Production of initial samples

SPECIAL MACHINE CONSTRUCTION

- Development of plant concepts
- Flexible production lines for single- or multi-purpose FSW processing
- Clamping device (semi- or fully automatic)

CUSTOMER

CONSULTING

- Optimised design of the component/workpiece
- Selection of suitable processes, options and alternatives
- Determination of the production parameters
- Development of concepts

CAPABILITIES

- Assessment of the feasibility
- Production of sample parts
- General conditions
- Cost/benefit analysis

INTEGRATION

- Assessment of the requisite infrastructure (space, energy requirement, etc.)
- Definition of the interfaces and system integration

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PROCESS DEVELOPMENT

- FSW parameter studies in the HAGE Competence Center
- FSW tool development
- Process stability and optimisation
- Force analyses
- Implementation of various studies (e.g. RPT, Bobbin Tool)

PROCESS OPTIMISATION

- Reduction in cycle times
- Increase in welding speed
- Increase in tool lifetime
- Process certificates
- Operator training

PROCESS MONITORING

- Real-time process monitoring
- Measuring process parameters up to 100 kHz (force, torque, position, speed, etc.)
- Analysis of welding defects
- Real-time communication with the machine controller
- 3D geometry scan of the weld joint

INITIAL PHASE

- Acquisition of technology know-how/empirical values
- Training, certification of the employees
- Preparation of the procedural instructions

(SERIES) PRODUCTION

- Systematic increase of the process stability
- Documentation and monitoring of the process
- Machine protection
- Optimisation of the component and the FSW process

THE HAGE FSW EXPERTISE

As our customer, you need to be certain you are choosing the right welding process. We do everything necessary to support you in that decision. We draw on all the experience of our FSW experts to develop a feasible concept. Precision and process reliability are assured by design and by testing in our competence centre. We know how challenging it can be to integrate a new technology into an existing manufacturing process. We have done it successfully many times, and we will help you do it, too.

HAGE GANTRY PROCESSING SYSTEM (FSW Competence Center incl. process monitoring)

for development, demonstration and job order production purposes

Working range:
20 m x 3 m x 1.6 m

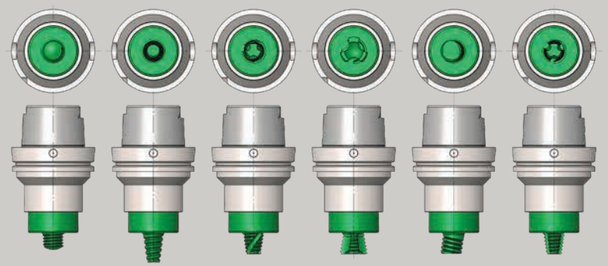
HAGE FSW SYSTEM IN THE IN-HOUSE COMPETENCE CENTER

- Geometrical testing
- Process and parameter studies
- Position- and force-controlled welding
- Development of clamping concepts
- Production of prototypes

FSW TOOLS

Drawing on deep engineering experience, the HAGE FSW experts are able to develop tools that are precisely suited to each specific process. Tools have to satisfy a range of different demands. In particular, the tool material must retain its strength at high welding temperatures. Tools for welding light metals such as aluminium or magnesium are usually made of heat-treated hot work steel.

The choice of material also has a strong influence on the service life of the tool. Tools can be made of one part, multiple parts or can also be designed specially for spot welding.

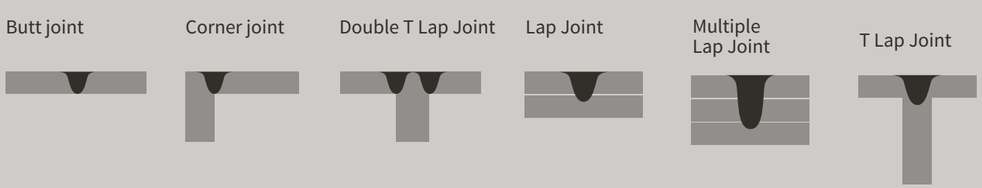


YOUR ADVANTAGE:

- Higher welding speeds
- Improved quality
- Longer tool life
- Component optimisation

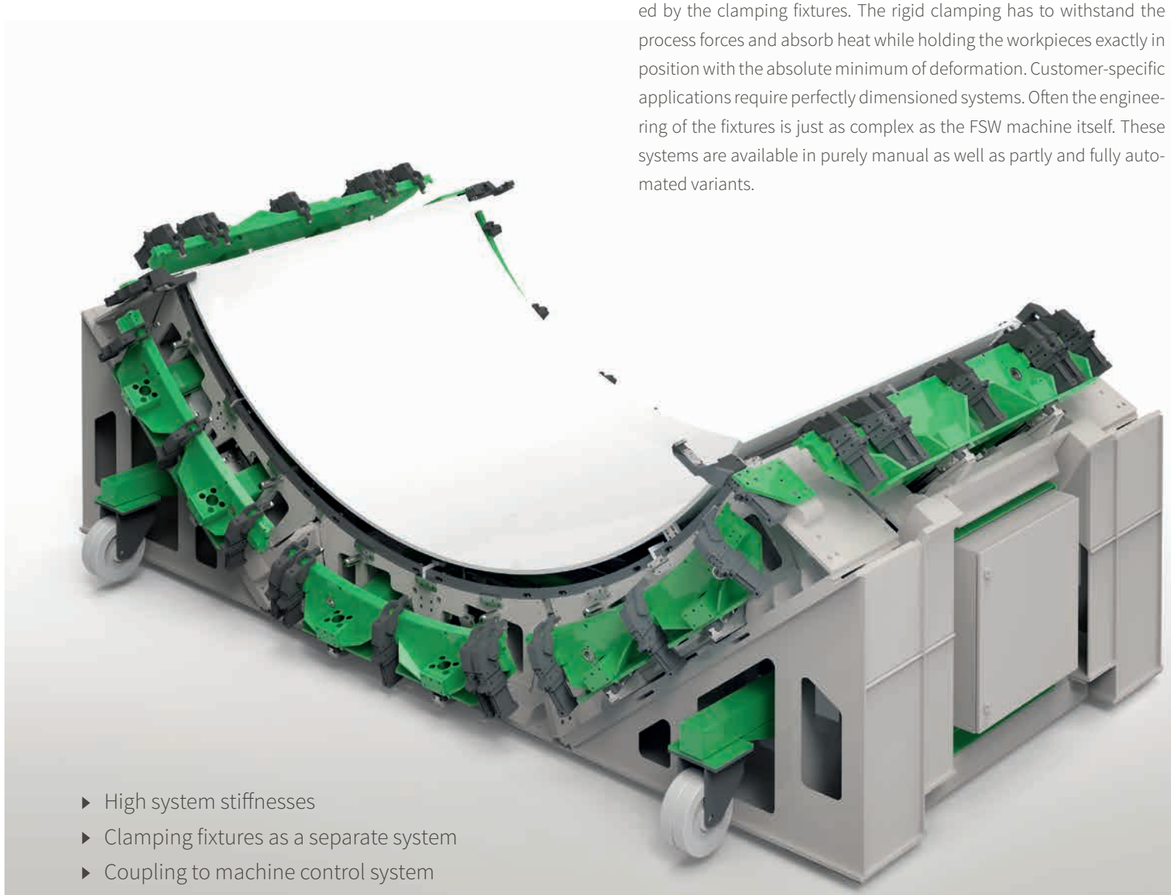
CORRECT TOOL SELECTION:

- Workpiece tolerances
- Speed optimisation
- Joint types
- Welding depth



FSW CLAMPING FIXTURES

A crucial role in successful welding of precision parts using FSW is played by the clamping fixtures. The rigid clamping has to withstand the process forces and absorb heat while holding the workpieces exactly in position with the absolute minimum of deformation. Customer-specific applications require perfectly dimensioned systems. Often the engineering of the fixtures is just as complex as the FSW machine itself. These systems are available in purely manual as well as partly and fully automated variants.

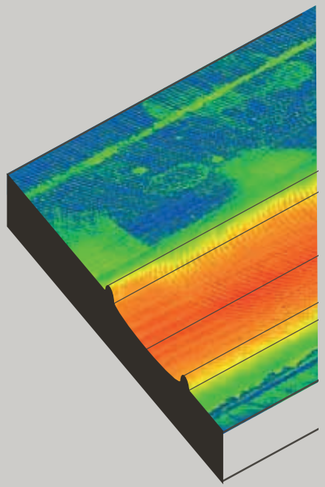


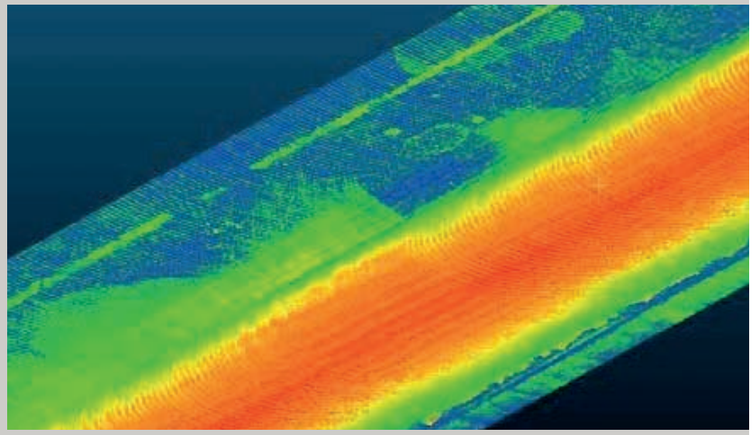
- High system stiffnesses
- Clamping fixtures as a separate system
- Coupling to machine control system
- Hydraulic, pneumatic and electrical alignment and clamping technology
- Optimised design to achieve and maintain the required tolerances

HAGE FSW WELD CHECK

Optimally designed to the engineering and the customer-specific process, the „WeldCheck“ monitoring system acquires all the relevant process parameters of the system, evaluates them in real time and is responsible for the quality assurance of each FSW joint. A bi-directional communication interface between WeldCheck and the machine controller also enables welding defects to be reported and triggers an immediate response from the machine.

- Online process monitoring and error analysis
- Geometry acquisition as a quality characteristic and for process optimisation
- Real-time visualisation of the acquired parameters
- Unambiguous identification of all weld joints
- Fully automatic creation of post processor data
- Raw data store for offline viewing and offline processing
- Evaluation on the basis of standard-related regulations
- Long-term archivable process document for quality assurance





Real-time evaluation of the visualised depth information of the weld

HAGE FSW WELD GUN

Die HAGE FSW WeldGun is a flexible solution for friction stir spot welding (FSSW for short), a special form of friction stir welding. Depending on the customer requirements, the concept can be stationary or mounted on industrial robots, e.g. in order to weld car body parts.

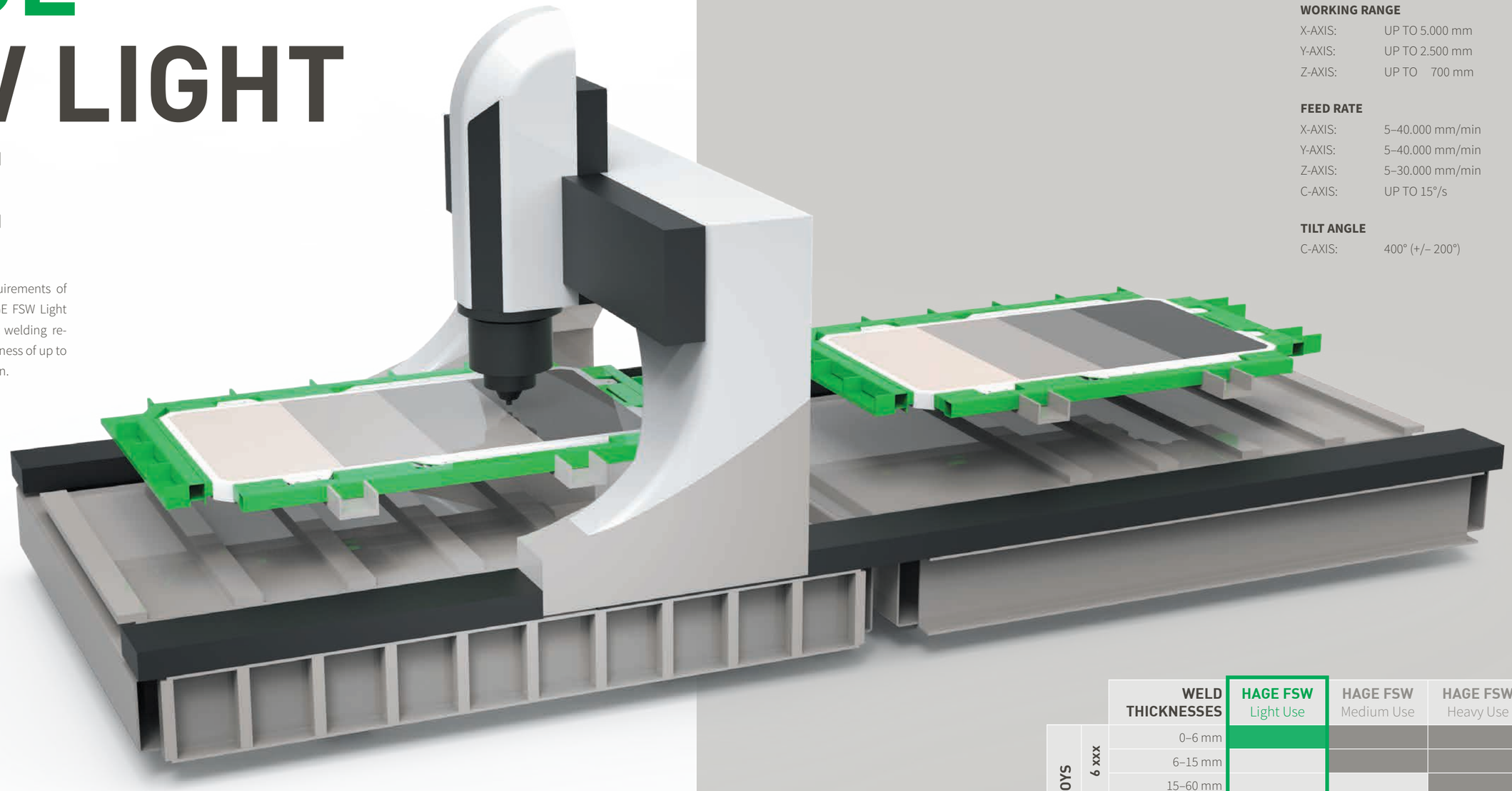
The WeldGun is also perfect for step welds. There is no impairment of the visible surface in this respect. The special structure enables the spot to be placed not visible.

TECHNICAL DATA:

MAX. AXIAL FORCES:	8 kN
OPENING STROKE:	150 mm
SPEED:	3.500 rpm
WELDING TIME:	2–3 s/spot
TOTAL WEIGHT:	80 kg

HAGE
FSW LIGHT USE

Especially developed for the requirements of the automotive industry, the HAGE FSW Light Use proves itself through perfect welding results. Light alloys with a weld thickness of up to 6 mm are joined with high precision.



HIGHLIGHTS:

- Highly rigid FEM-calculated machine concept
- Siemens 840D sl or FANUC CNC, Safety Integrated
- Force measuring system
- Force and position control
- Adjustable lead angle (also via NC axis as an option)
- C-axis for readjustment of the FSW spindle
- HAGE FSW WeldCheck for process monitoring

TECHNICAL DATA:

WORKING RANGE

X-AXIS:	UP TO 5.000 mm
Y-AXIS:	UP TO 2.500 mm
Z-AXIS:	UP TO 700 mm

FEED RATE

X-AXIS:	5–40.000 mm/min
Y-AXIS:	5–40.000 mm/min
Z-AXIS:	5–30.000 mm/min
C-AXIS:	UP TO 15°/s

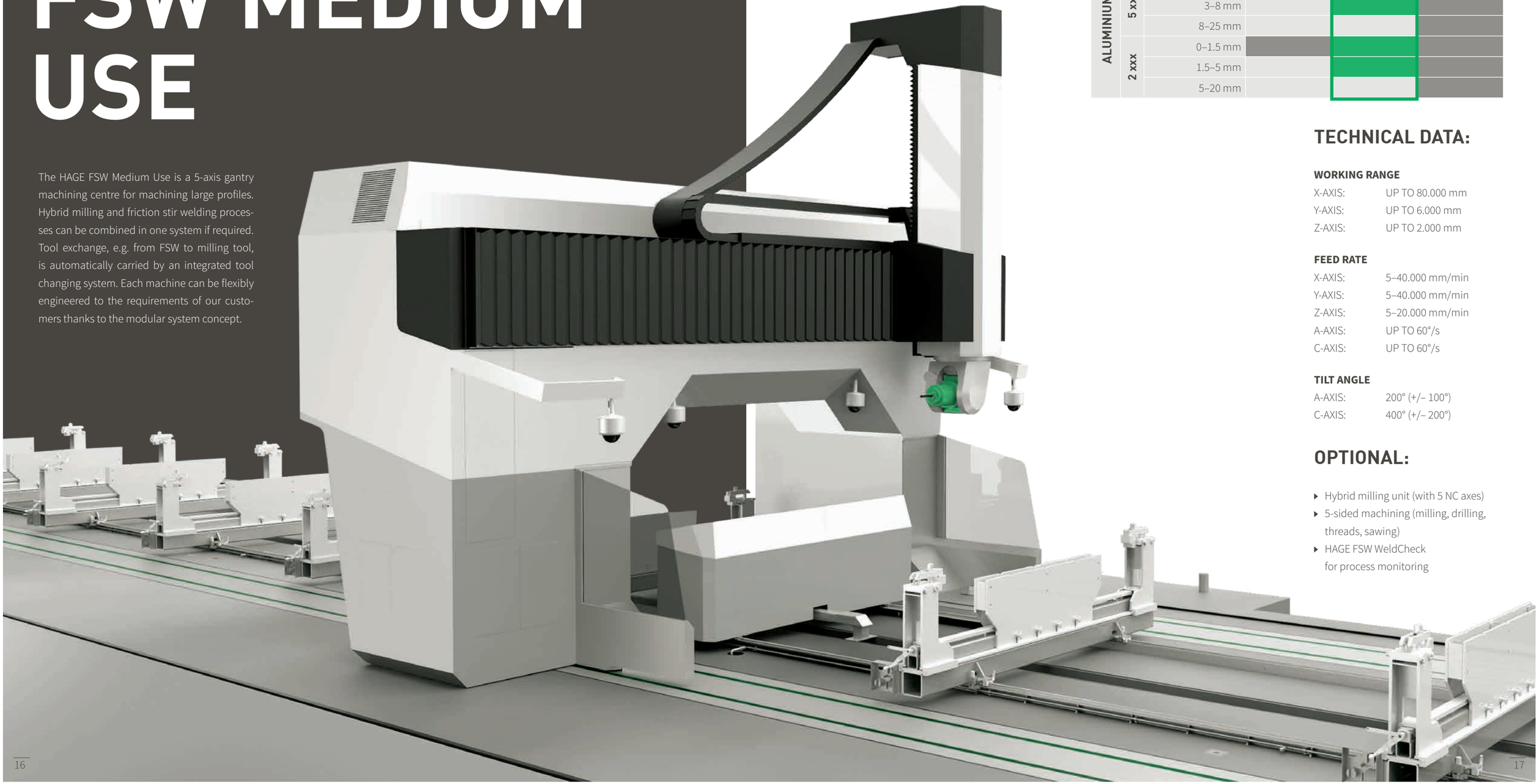
TILT ANGLE

C-AXIS:	400° (+/– 200°)

	WELD THICKNESSES	HAGE FSW Light Use	HAGE FSW Medium Use	HAGE FSW Heavy Use
ALUMINIUM ALLOYS 6 xxx	0–6 mm	■	■	■
	6–15 mm		■	■
	15–60 mm			■
ALUMINIUM ALLOYS 5 xxx	0–3 mm	■	■	■
	3–8 mm		■	■
	8–25 mm			■
ALUMINIUM ALLOYS 2 xxx	0–1.5 mm	■	■	■
	1.5–5 mm		■	■
	5–20 mm			■

HAGE
FSW MEDIUM USE

The HAGE FSW Medium Use is a 5-axis gantry machining centre for machining large profiles. Hybrid milling and friction stir welding processes can be combined in one system if required. Tool exchange, e.g. from FSW to milling tool, is automatically carried by an integrated tool changing system. Each machine can be flexibly engineered to the requirements of our customers thanks to the modular system concept.



	WELD THICKNESSES	HAGE FSW Light Use	HAGE FSW Medium Use	HAGE FSW Heavy Use
ALUMINIUM ALLOYS 6 xxx	0–6 mm			
	6–15 mm			
	15–60 mm			
ALUMINIUM ALLOYS 5 xxx	0–3 mm			
	3–8 mm			
	8–25 mm			
ALUMINIUM ALLOYS 2 xxx	0–1.5 mm			
	1.5–5 mm			
	5–20 mm			

TECHNICAL DATA:

WORKING RANGE

X-AXIS:	UP TO 80.000 mm
Y-AXIS:	UP TO 6.000 mm
Z-AXIS:	UP TO 2.000 mm

FEED RATE

X-AXIS:	5–40.000 mm/min
Y-AXIS:	5–40.000 mm/min
Z-AXIS:	5–20.000 mm/min
A-AXIS:	UP TO 60°/s
C-AXIS:	UP TO 60°/s

TILT ANGLE

A-AXIS:	200° (+/– 100°)
C-AXIS:	400° (+/– 200°)

OPTIONAL:

- Hybrid milling unit (with 5 NC axes)
- 5-sided machining (milling, drilling, threads, sawing)
- HAGE FSW WeldCheck for process monitoring

HAGE
FSW HEAVY USE

The HAGE FSW Heavy Use is a 5-axis gantry machining centre for machining large profiles of all light metals. The system concept offers complete friction stir welding processes and optionally also milling processes through an additional milling unit.

Like all HAGE systems, the HAGE FSW Heavy Use can also be individually tailored to the requirements of the customers.

HIGHLIGHTS:

- Gantry welding system with 7 NC axes (5 linear axes, 2 rotary axes)
- Separate pin/shoulder axis
- Path/force control, for both pin and shoulder axis
- Measuring systems for measuring all relevant process variables - Fz, Fy, Fx, Msp, n, etc.
- Self reacting / Bobbin tools
- Inline 3D scan of the weld
- Automatic NC code generation for optimum deburring
- HAGE FSW WeldCheck for process monitoring

OPTIONAL:

- Milling unit (with 5 NC axes)
- 5-sided machining (milling, drilling, threads, sawing)

TECHNICAL DATA:

WORKING RANGE

X-AXIS:	UP TO 80.000 mm
Y-AXIS:	UP TO 6.000 mm
Z-AXIS:	UP TO 2.000 mm

TYPICAL FSW MAIN SPINDLE

SPEED RANGE:	1.500 rpm
TORQUE:	302 Nm
MAX. AXIAL FORCE:	80 kN
MAX. RADIAL FORCE:	30 kN

FEED RATE OF FSW

X-AXIS:	40.000 mm/min
Y-AXIS:	10.000 mm/min
Z-AXIS:	10.000 mm/min
A-AXIS:	3°/s
C-AXIS:	10°/s

FEED RATE OF MILLING

X-AXIS:	40.000 mm/min
Y-AXIS:	40.000 mm/min
Z-AXIS:	20.000 mm/min
A-AXIS:	60°/s
C-AXIS:	60°/s

	WELD THICKNESSES	HAGE FSW Light Use	HAGE FSW Medium Use	HAGE FSW Heavy Use
ALUMINIUM ALLOYS 6 xxx	0–6 mm	■	■	■
	6–15 mm		■	■
	15–60 mm			■
ALUMINIUM ALLOYS 5 xxx	0–3 mm	■	■	■
	3–8 mm		■	■
	8–25 mm			■
ALUMINIUM ALLOYS 2 xxx	0–1.5 mm	■	■	■
	1.5–5 mm		■	■
	5–20 mm			■

HAGE
FSW HEAVY USE

STAND-MOUNTED VERSION

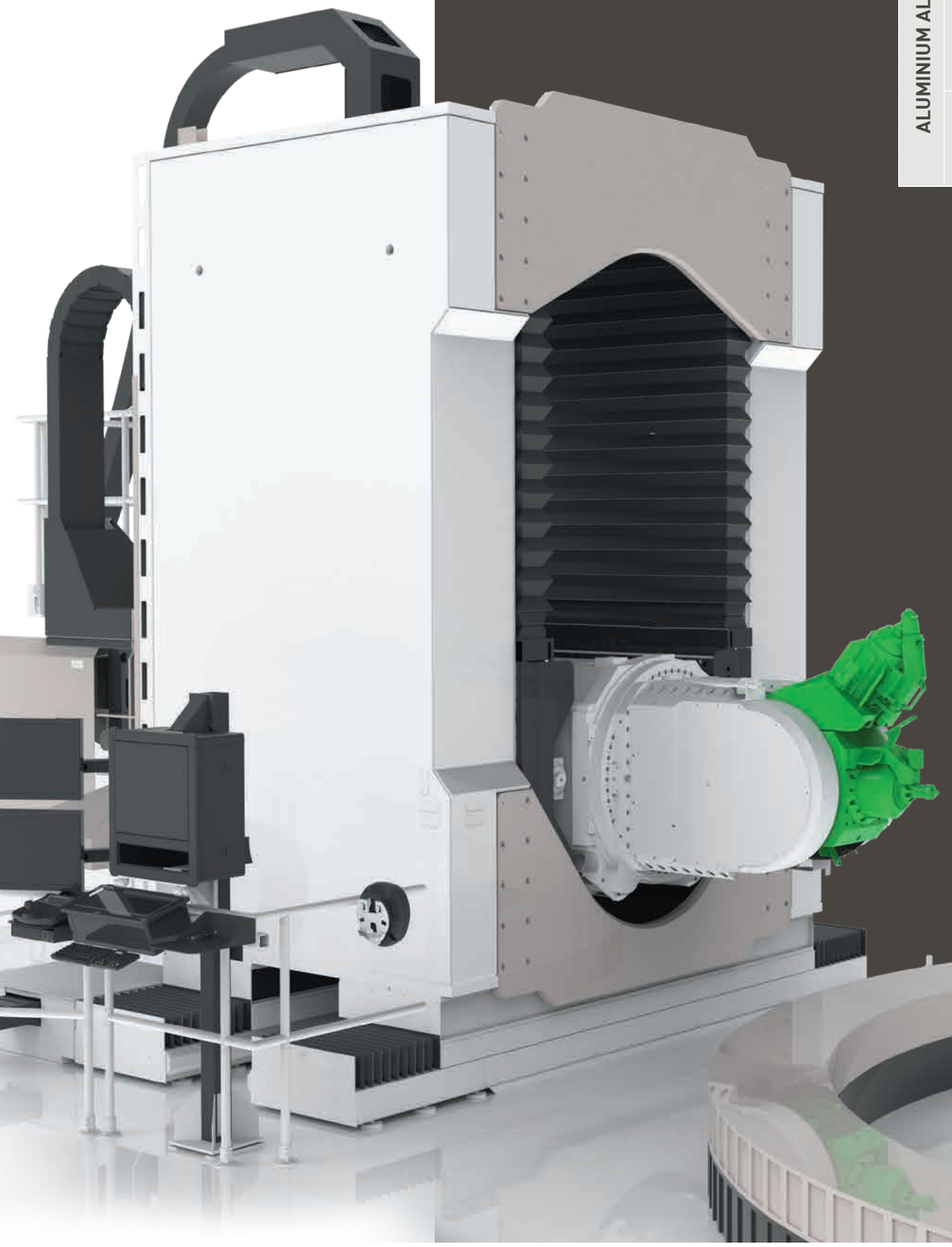
The HAGE FSW solutions are also available in a stand-mounted version with 7 axes. In functional terms, these also combine friction stir welding processes with optional milling processes. The design of the stand can be individually tailored to the technical requirements of the customers.

HIGHLIGHTS:

- Welding system with 7 NC axes (5 linear axes, 2 rotary axes)
- Separate pin/shoulder axis
- Position/force control, for both pin and shoulder axis
- Measuring systems for measuring all relevant process variables - Fz, Fy, Fx, Msp, n, etc.
- Self reacting / Bobbin tools
- Inline 3D scan of the weld
- Automatic NC code generation for optimum deburring
- HAGE FSW WeldCheck for process monitoring

OPTIONAL:

- Milling unit (with 5 NC axes)
- 5-sided machining (milling, drilling, threads, sawing)



	WELD THICKNESSES	HAGE FSW Light Use	HAGE FSW Medium Use	HAGE FSW Heavy Use
ALUMINIUM ALLOYS 6 xxx	0–6 mm			
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	15–60 mm			
ALUMINIUM ALLOYS 5 xxx	0–3 mm			
	3–8 mm			
	8–25 mm			
ALUMINIUM ALLOYS 2 xxx	0–1.5 mm			
	1.5–5 mm			
	5–20 mm			

TECHNICAL DATA:

WORKING RANGE

X-AXIS:	UP TO 60.000 mm
Y-AXIS:	UP TO 5.000 mm
Z-AXIS:	UP TO 2.000 mm

FEED FORCE

X-AXIS:	UP TO 80 kN
Y-AXIS (VERTICAL):	UP TO 80 kN
Z-AXIS (HORIZONTAL):	UP TO 80 kN

TYPICAL FSW MAIN SPINDLE

SPEED RANGE:	1.500 rpm
TORQUE:	302 Nm
MAX. AXIAL FORCE:	80 kN
MAX. RADIAL FORCE:	30 kN

FEED RATE OF FSW

X-AXIS:	20.000 mm/min
Y-AXIS:	10.000 mm/min
Z-AXIS:	10.000 mm/min
A-AXIS:	UP TO 3°/s
C-AXIS:	UP TO 10°/s

TILT ANGLE

A-AXIS:	200° (+/– 100°)
C-AXIS:	400° (+/– 200°)

ACCELERATION

UP TO 1.0 m/s^2

HAGE FSW FLEXIBLE USE

The HAGE FSW Flexible Use special solutions for fully automatic production of customer-specific workpieces provide the highest level of individualisation. The FSW process can be integrated in automation lines.

To increase the plant throughput, the loading and unloading of the materials can also be provided automatically, e.g. by means of inlet and outlet buffers or stacking in transport containers. Raw materials which have excessive tolerances are optimally formed for the FSW process e.g. by a calibration and preparation station.

If required by the cycle time, the workpiece can be processed simultaneously by several FSW units. This means that the welding time can be significantly reduced even further.

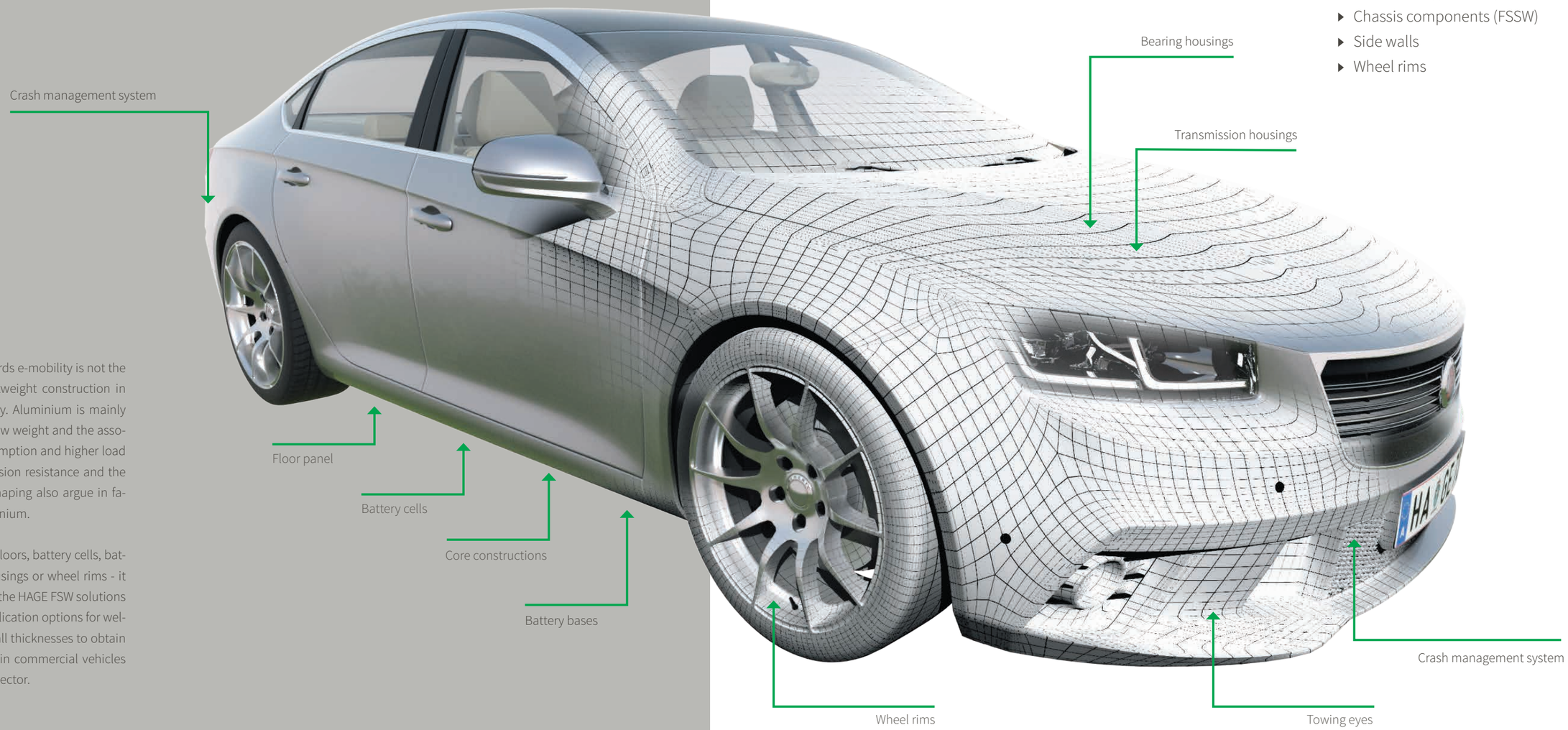
STATIONS OF THE HAGE FSW FLEXIBLE USE FOR MANUFACTURING OF FLOOR PANELS FOR TRUCKS

- Inlet buffer
- Calibration station
- Outfeed roller conveyor
- Conveying system
- Clamping device
- FSW process
- Edging station
- Chip extraction
- Safety equipment

AUTOMOTIVE INDUSTRY

The development towards e-mobility is not the only key driver of lightweight construction in the automotive industry. Aluminium is mainly used as a result of its low weight and the associated lower fuel consumption and higher load weight. However, corrosion resistance and the excellent options for shaping also argue in favour of the use of aluminium.

Loading walls, loading floors, battery cells, battery bases, bearing housings or wheel rims - it makes no difference as the HAGE FSW solutions provide a variety of application options for welding a wide range of wall thicknesses to obtain smooth surfaces, both in commercial vehicles and in the automotive sector.



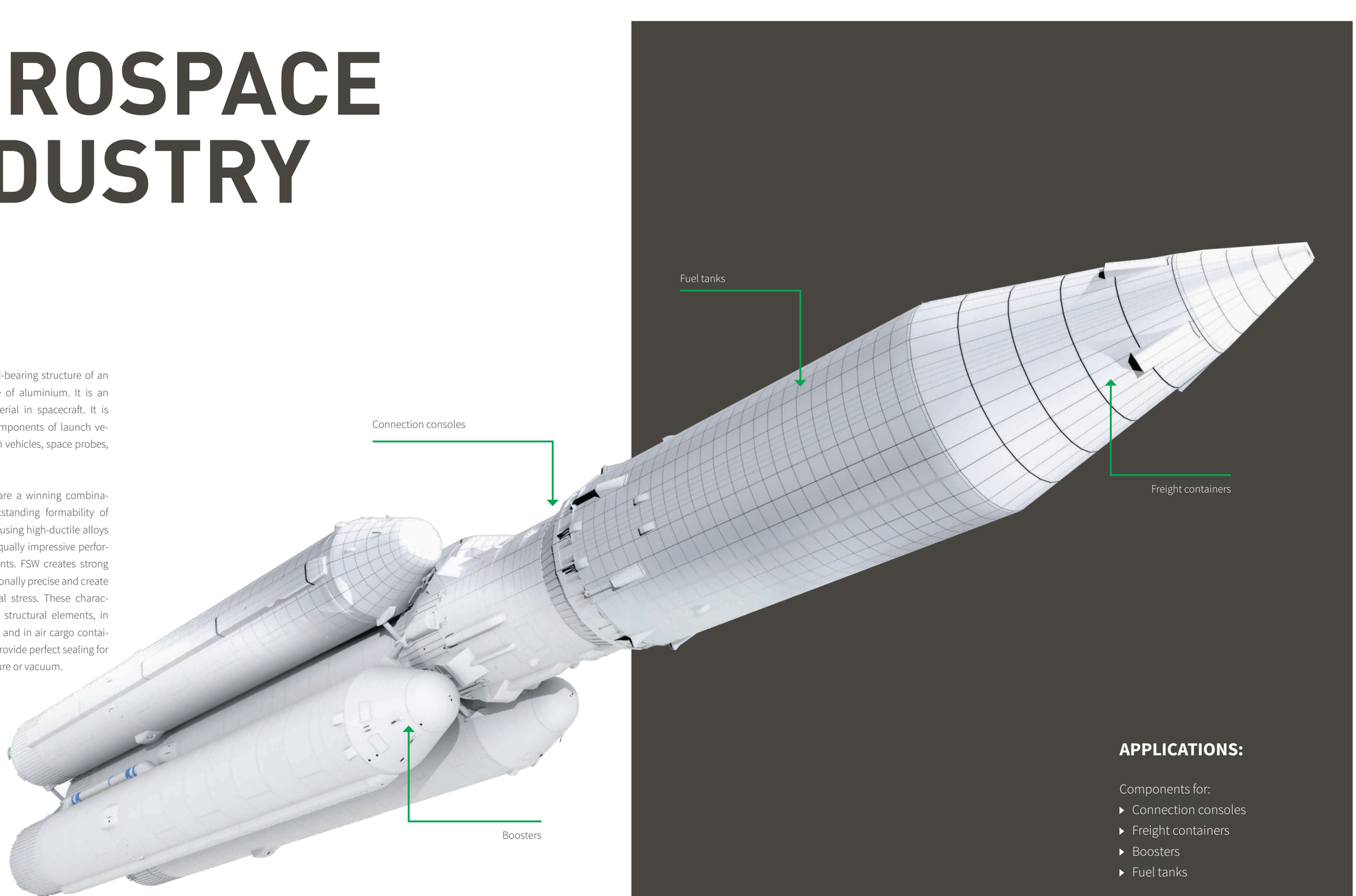
APPLICATIONS:

- Battery bases
- Battery cells
- Transmission housings
- Bearing housings
- Core constructions
- Floor panels
- Towing eyes
- Crash management systems
- Chassis components (FSSW)
- Side walls
- Wheel rims

AEROSPACE INDUSTRY

Up to 80% of the load-bearing structure of an aircraft may be made of aluminium. It is an equally essential material in spacecraft. It is used for structural components of launch vehicles, reusable launch vehicles, space probes, and fuel tanks.

Aluminium and FSW are a winning combination because the outstanding formability of the metal – especially using high-ductile alloys – is matched by the equally impressive performance of the FSW joints. FSW creates strong joints that are dimensionally precise and create a minimum of internal stress. These characteristics all pay off in structural elements, in aircraft cabin furniture and in air cargo containers. FSW welds also provide perfect sealing for joints subject to pressure or vacuum.



APPLICATIONS:

Components for:

- Connection consoles
- Freight containers
- Boosters
- Fuel tanks

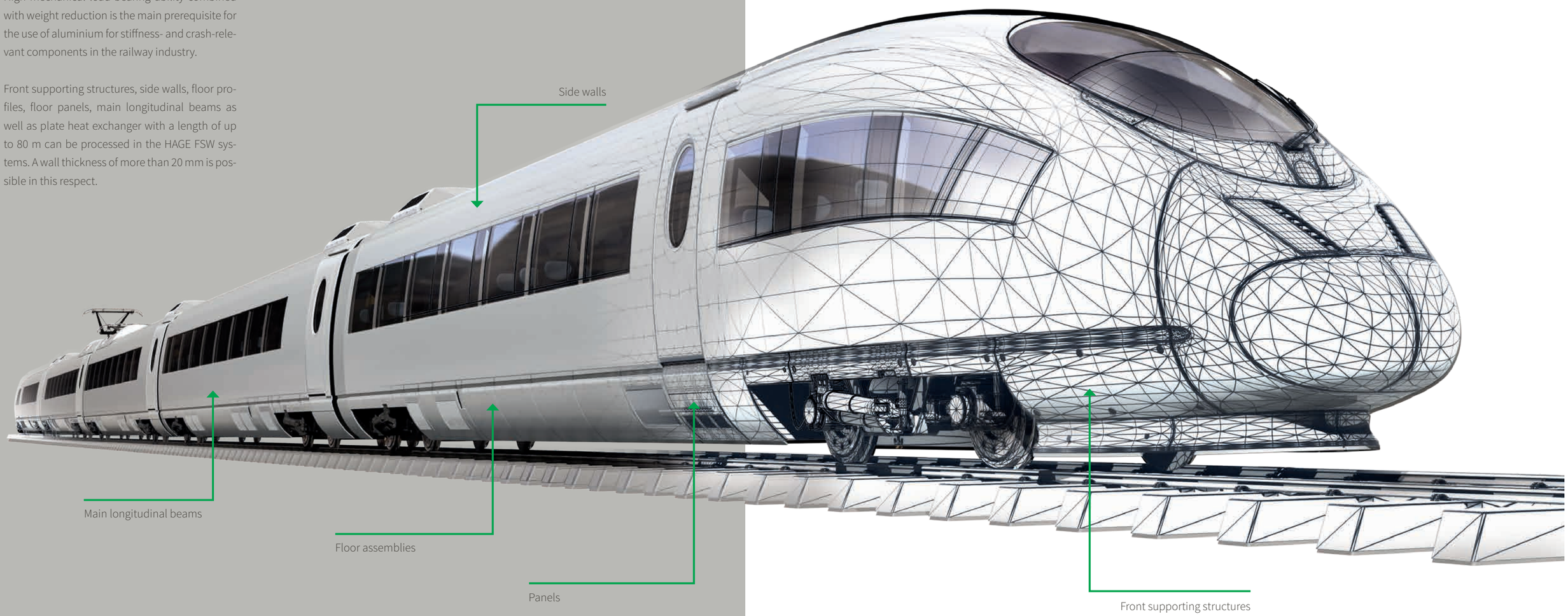
RAILWAY INDUSTRY

High mechanical load-bearing ability combined with weight reduction is the main prerequisite for the use of aluminium for stiffness- and crash-relevant components in the railway industry.

Front supporting structures, side walls, floor profiles, floor panels, main longitudinal beams as well as plate heat exchanger with a length of up to 80 m can be processed in the HAGE FSW systems. A wall thickness of more than 20 mm is possible in this respect.

APPLICATIONS:

- Front supporting structures
- Panels
- Main longitudinal beams
- Floor assemblies
- Side walls



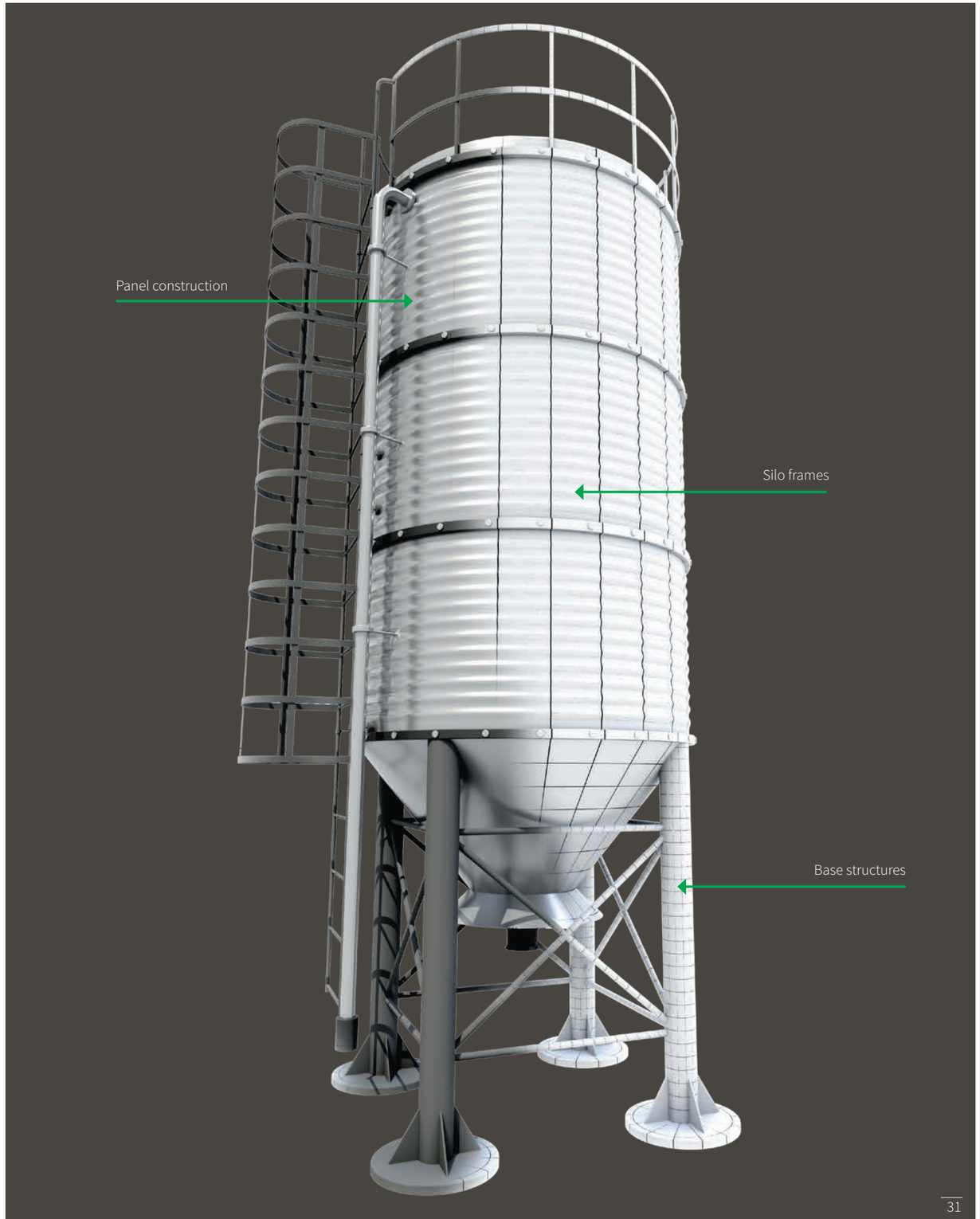
INDUSTRIAL PLANT AND OTHER INDUSTRIES

The prevalence and the large number of applications of FSW technology can be seen in plant engineering. Aluminium silos are used in the plastics, food and chemical industries and have proven themselves due to their cleanliness and lasting visual appeal.

The process plays an important role in crane construction and shipbuilding. Significant weight reductions combined with an increase in the useful load as well as the high bending strength argue in favour of the use of aluminium and FSW joints. Aluminium alloys with high corrosion resistance which are suitable for seawater applications are also used for various crane components as well as ship floors, walls and ceilings up to 20 m. The advantages of the FSW technology increase the stability and durability of the joints.

APPLICATIONS:

- Crane components
- Ship panels
- Silos



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