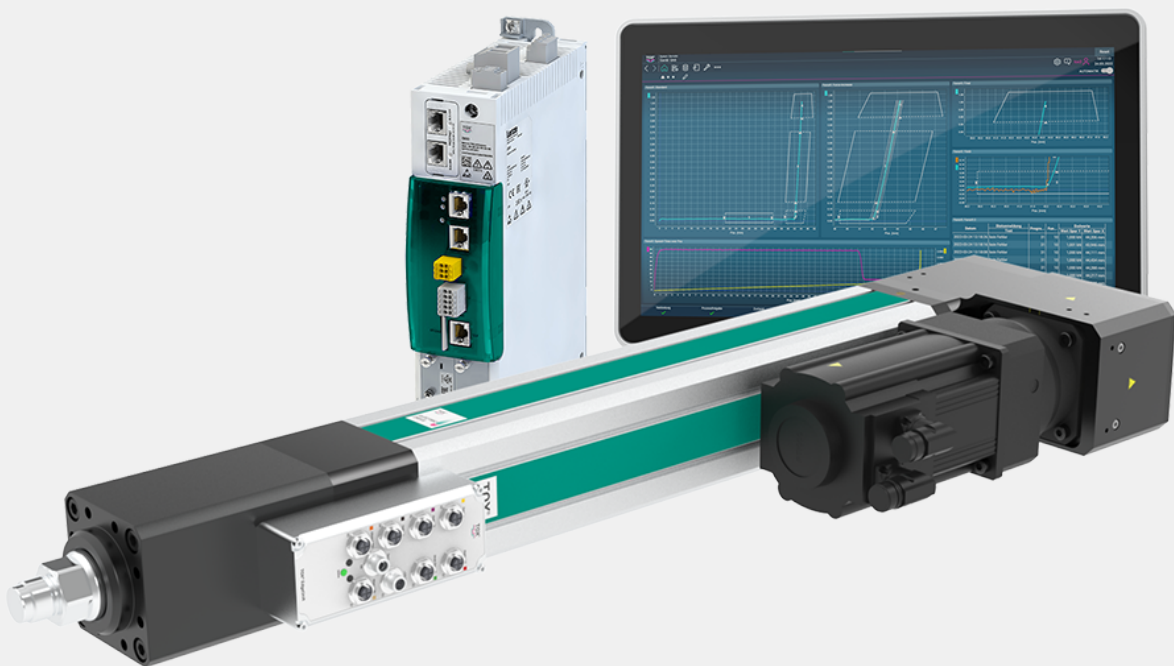


Whitepaper

Flexible servo presses in modern production



Flexible servo presses in modern production

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Flexible servo presses in modern production

Abstract

How modular joining modules make complex pressing processes manageable and enable production flexibility

What this whitepaper is about

This whitepaper demonstrates why flexibility in modern pressing processes is not merely a feature, but a technical and economic necessity.

The focus is on wide power ranges, short travel distances with high dynamics, longer holding phases, external sensor integration, and the question of how processes can be adapted and reliably monitored in day-to-day plant operations.

Modern joining processes today must do much more than simply press parts together. They must precisely control forces and strokes, verify process quality, accommodate different component variants and be adaptable to new requirements. This is precisely where electromechanical servo presses come into play.

TOX® ElectricDrive Core combines the drive, controller, sensor integration and software into a fully integrated servo press system.

The technical value of this system lies not only in its maximum power, but also in its ability to replicate, adapt and monitor complex processes across a wide range of conditions.

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Executive Summary

Production processes in industrial production are becoming increasingly complex. New technologies such as electric mobility, battery production, hydrogen systems and electronics assembly are placing growing demands on joining systems.

Nowadays, pressing processes often need to simultaneously meet requirements such as high forces, large stroke ranges, precise force control, high dynamics over short travel distances, long holding times and comprehensive process monitoring. Furthermore, the pressing process is often not yet fully defined at the start of a project.

Material behaviour, component tolerances, holding times or additional quality characteristics often only become apparent during commissioning, testing and the start of series production. This is precisely why flexibility in the joining technology used is so important.

TOX® ElectricDrive Core is designed as a servo press system that addresses this uncertainty through its design: with modular drive options, integrated process monitoring, external sensor integration via the TOX® EdgeUnit, and software that allows customers to configure and optimise their processes themselves.

Technical classification

Pressure range of the system:

0,02 to 1000 kN

Path repeatability:

0,01 mm

High dynamics:

speeds of up to 800 mm/s and acceleration of up to 8000 mm/s², depending on the series

Sensors:

integrated force/displacement sensors, external force/displacement sensors via TOX® EdgeUnit

Stops:

from milliseconds to longer holding times, and depending on the design, even up to several hours

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1. The reality of modern pressing processes

In many industries, production requirements are changing at a faster pace than before. Shorter product life cycles, an increasing variety of variants, new materials and stricter quality requirements mean that pressing processes must now be considered in a much more nuanced way than was the case just a few years ago.

What does this mean for plant engineers and manufacturers?

During the concept phase, the pressing process is often only partially understood. The basic joining task is clear, but not every detail regarding component tolerances, material behaviour, additional steps or the subsequent quality criteria.

A good servo press system must therefore not only meet the initial requirements, but also allow scope for further development.

Typical requirements include combinations of pressing forces ranging from a few hundred newtons to several hundred kilonewtons, travel distances from a few millimetres to over a metre, and holding times from milliseconds to longer periods of minutes or – depending on the design – hours. It is precisely this combination that makes modern applications technically interesting.

What does this mean for TOX® servo press systems?

- Covering large work areas with a single system
- Adaptability to different components and materials
- Design with capacity for future requirements
- Ensuring stable processes despite complexity

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2. Why traditional press systems reach their limits here

Pneumatic, hydraulic or purely mechanical presses still have their place. However, they reach their limits when a process needs to be precise, flexible and fully monitorable at the same time.

They are often designed for a smaller force range, are more difficult to adapt to new motion profiles, or are only partially equipped to accommodate additional sensors.

If requirements change during the course of a project, this can quickly lead to the need for additional press stations, mechanical modifications or complex custom solutions.

This increases costs and complexity – particularly if the system is later required to handle multiple product variants or process steps using the same station.

What does this mean for TOX® servo press systems?

- Design for variable force and motion profiles
- Configurable adaptation to changing process requirements
- Expandability for the integration of additional sensors
- Support for end-to-end process monitoring
- Reduction in design modifications and additional stages

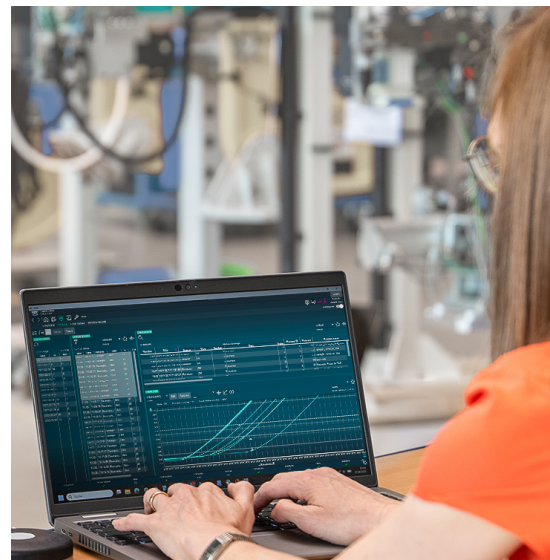


Figure 1: Digital process monitoring in production

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3. The TOX® System at a glance

TOX® ElectricDrive Core is not a single actuator, but a coordinated servo-press system. The TOX® ElectricPowerDrive generates the linear pressing motion via a servo motor, gearbox and threaded spindle.

The TOX® PowerModule Core controls force, displacement, speed and acceleration. The TOX® EdgeUnit provides additional sensor technology and decentralised signal acquisition directly at the drive. The TOX® software is used for parameterisation, visualisation, data storage and process monitoring.

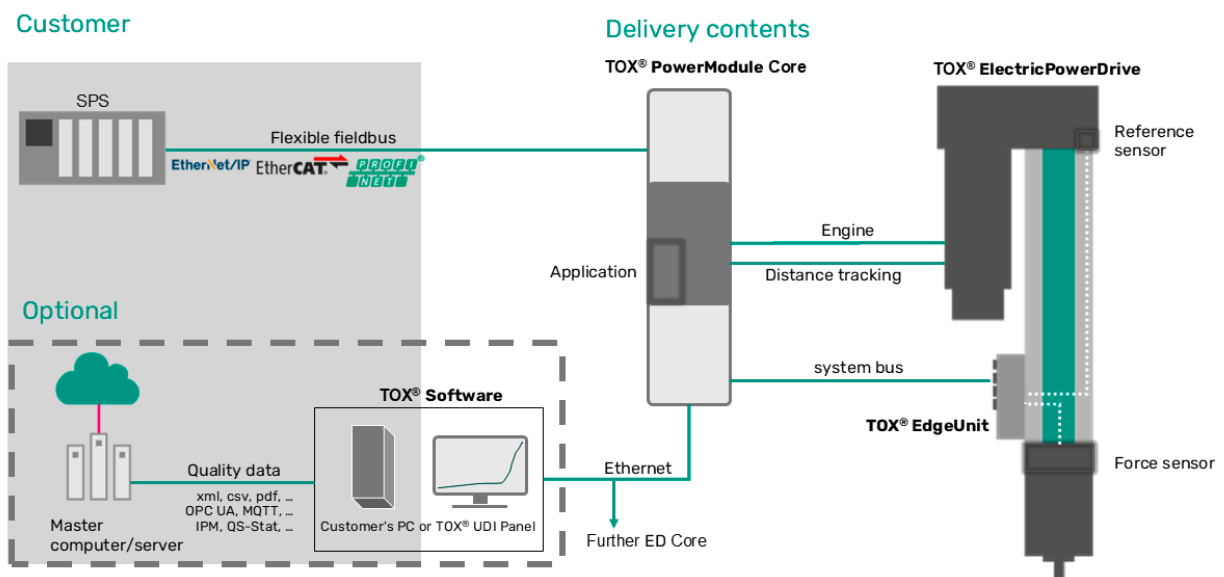
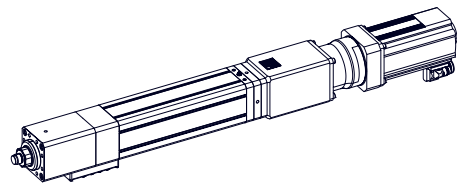


Figure 2: System overview

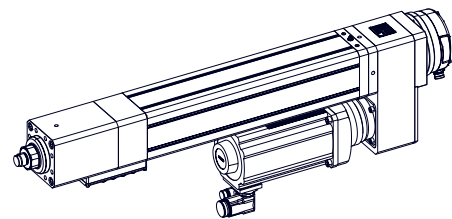
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Depending on the application, a range of drive characteristics is available: EQe-K for cost-effective standard applications, EXe-K for flexible joining tasks, EXe-F for particularly high dynamics, and EXe-L for very high pressing forces.

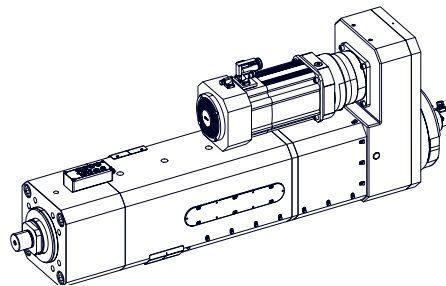
The system is complemented by application-specific versions, for example for longer strokes, IP65, cleanroom environments, extra-short or extra-narrow designs, as well as additional sensor technology.



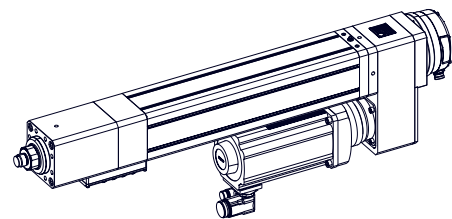
Type EXe-F



Type EXe-K



Type EXe-L



Type EQe-K

Figure 3: ElectricDrive model overview

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4. Wide power-ranges: not between two products, but within the process itself

One point is often misunderstood in practice:

Wide power-ranges do not arise simply because a delicate electronic component is produced one day and a heavy-duty assembly part the next. Very different force levels often occur within the same pressing process.

A typical example is a press-fitting process that requires around 100 kN during the main phase, but where additional forces of around 1 kN – such as those caused by snagging, clipping or seating – must also be reliably detected and analysed.

From a technical point of view, it is not enough simply to control the maximum pressing force. The servo press must also be able to accurately detect and evaluate even minor deviations in the force curve, and distinguish them from the rest of the process in a reproducible manner.

This is precisely where the measurement and control architecture comes into its own. TOX® uses integrated force sensors based on strain gauges (SG). This sensor technology is suitable for both static and dynamic force measurements and provides a stable basis for processes in which not only the maximum force value but also the entire force curve is relevant.

The TOX® EdgeUnit also allows external force transducers, displacement sensors and encoders to be integrated. This is particularly useful when measurements need to be taken closer to the tool or directly on the workpiece, regardless of the bending configuration (C-frame, 2/4-column frame) or temperature, or when the process requires additional accuracy in the lower force range.

The strength of the system therefore lies not only in the pressing force itself, but in the ability to adapt the measurement strategy to the application.

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5. Holding times and stable strength signals

In many applications, the process does not end once the target force has been reached. Forces often need to be held for a certain period of time – ranging from very brief intervals of a few milliseconds to longer holding times of seconds, minutes or, in specialised applications, even longer.



Sensor technology is crucial for tasks of this kind. Strain gauge-based force sensors are widely used precisely because they are well suited to both static and dynamic measurement tasks. In the TOX®-system, the integrated force measurement is designed in such a way that even longer holding phases can be monitored with a stable force signal.

At the same time, from a technical standpoint, it is clear that actual long-term behaviour always depends on the overall system – including temperature, mechanical factors, material relaxation and control strategy.

It is also important to distinguish between maintaining force and controlling force. If force is actively controlled, the drive remains within the control loop. If force is maintained via braking or holding functions, this represents a different physical state. For the correct design, it is therefore always necessary to consider what level of stability the specific process actually requires and for how long.



Hold force:

Once the nominal value has been reached, the force is held by the safety brake or motor holding brake. The power supply between the controller and the motor can be switched off.

-  safe and energy-efficient
-  No continuous readjustment; A slight reduction in force depends on the specific application.

Control force:

The drive remains in control mode and actively adjusts to changes in load or material.

-  a consistent force over defined periods of time.
-  The design of the gearbox, motor, controller and thermal system must be suitable for the application.

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6. Accuracy of travel and position

In addition to force, position data is a key process parameter. Depending on the system configuration, TOX® operates using resolvers and, optionally, external position sensors. Typical positional repeatability is around 0.01 mm once the system has reached the thermally stable condition. For many joining processes, it is precisely this combination of repeatable position control and a clean force signal that forms the basis for reproducible quality.

External displacement sensors, which can be integrated via the TOX® EdgeUnit, are always a good choice when measurements need to be taken directly at the relevant process point, or when component tolerances, flexibilities, temperature effects or the behaviour of the tool and fixture cannot be adequately captured by the system's internal displacement measurement.

In addition, it is possible to switch flexibly between the resolver's internal position signal and an external position sensor during the process. Both signals can be recorded in parallel and displayed on a graph. This provides transparency in the process and expands the scope for analysis and optimisation.

Furthermore, the TOX® ElectricDrive Core System can also take into account factors such as the elastic deflection of the entire system, provided these have been determined in advance. This is relevant, for example, in the case of C-frames, 2-column or 4-column frames. In such cases, the target position is corrected in the application logic based on the force applied, so that the actual desired position on the component is reached despite the deflection.

An example illustrates the principle:

With a bending stiffness of 40 kN/mm and a process force of 20 kN, the resulting deflection is 0.50 mm. If a position of 100.00 mm is to be reached on the component, the system moves to 100.50 mm.

This compensates for the deflection, ensuring that the actual position on the component remains correct. This increases reproducibility and improves process accuracy, particularly when dealing with high forces and tight tolerances.

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7. High dynamics: why acceleration over short distances is so important

Many applications do not travel long distances, but only a few millimetres. In precisely these cases, the maximum speed often does not determine the actual cycle time. What matters far more is how quickly the drive can accelerate and decelerate.

TOX® meets this requirement with a range of drive characteristics. During flexible EXe-K variants can achieve high accelerations of up to 3000 mm/s² depending on their size, the EXe-F is designed for particularly high dynamics and can reach up to 8000 mm/s² as well as travel speeds of up to 800 mm/s.

For processes involving very short distances, high volumes or tight cycle times, this dynamism is often the key to boosting productivity.

| 30 mm travel with an acceleration of 1.5 m/s ² and a maximum speed of 200 mm/s Travel time = 0.294 s | 30 mm travel with an acceleration of 8 m/s ² and a maximum speed of 200 mm/s Travel time = 0.195 s | 10 mm travel with an a cceleration of 1.5 m/s ² and a maximum speed of 110 mm/s Travel time = 0.175 s | 10 mm travel with an acceleration of 8 m/s ² and a maxi- mum speed of 200 mm/s Travel time = 0.095 s |
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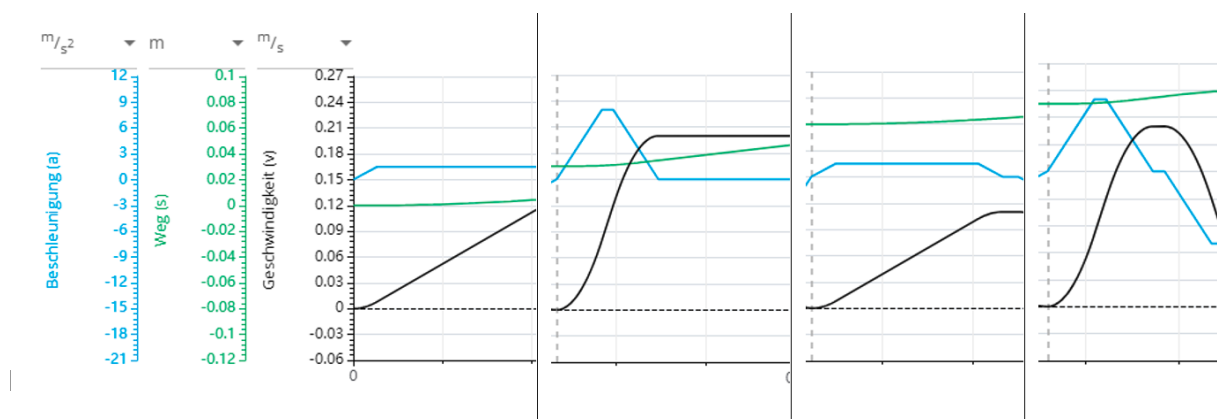


Figure 4: Technical diagram

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8. Freely definable monitoring windows instead of unclear process windows

The term ‘process window’ is often used loosely in everyday language. A more technically precise term is ‘freely definable monitoring windows’. This refers to tolerance ranges in force-displacement, force-time or displacement-time curves, within which the system checks whether the process is operating within the permissible limits.

Examples include an acceptable increase in force over a specific section of the stroke, a permitted force range during a holding phase, or monitoring whether a characteristic clip-in or seating event occurs at the correct position and with the expected force.

Such inspection windows turn a simple pressing cycle into a quality-assured process.

The TOX® software supports precisely this type of monitoring, featuring freely definable window and envelope curve techniques, as well as additional mathematical analysis and calculation functions.

For the customer, this means that the process is not only carried out, but also assessed in a transparent manner.

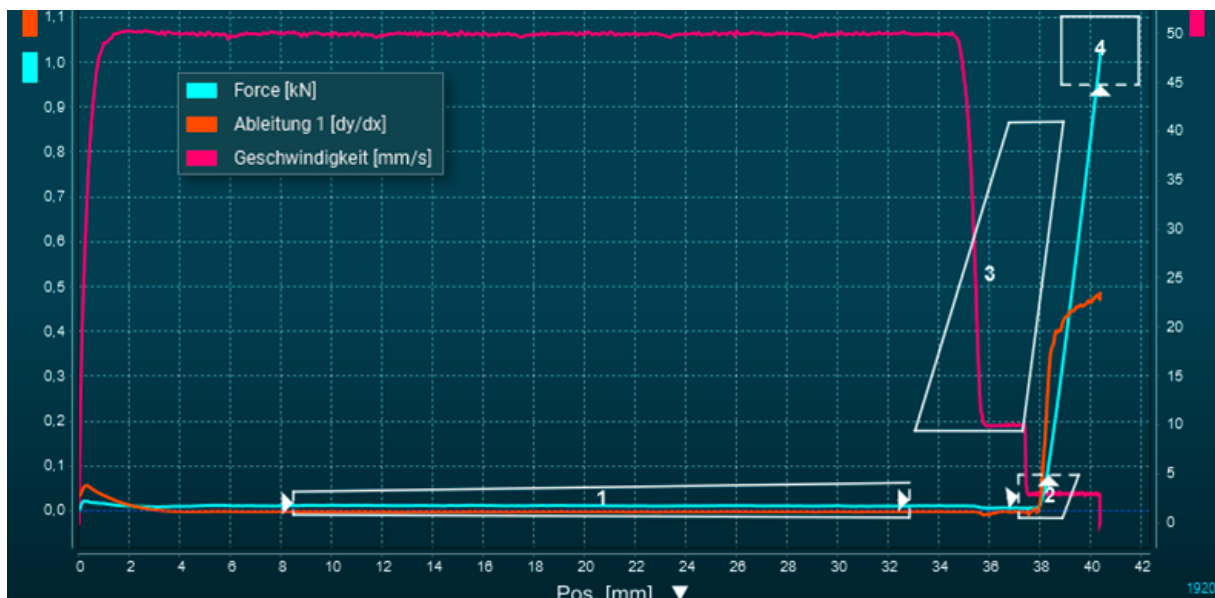


Figure 5: Force-displacement diagram

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9. Flexibility does not mean arbitrarily adding any feature

Flexibility does not mean that any feature can be retrofitted at a later stage from any base model for any reason. Protection classes, cleanroom versions or specific designs must be selected from the outset to suit the application.

In the context of TOX®, flexibility means something different: selecting the right model for the application from a well-designed system and then being able to further develop the process using software, sensors and parameterisation. This is precisely what significantly reduces the risk in the early stages of a project.

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10. Economic benefits for plant engineers and manufacturers

This technical flexibility has a direct economic impact. A servo-press system can often replace several specialised individual solutions, or at the very least handle a variety of joining tasks within a single production line.

This reduces system complexity, simplifies engineering and commissioning, and provides scope for future product modifications.

A particular advantage here is that changes often do not require mechanical modifications. In many cases, adjusting the settings, adding sensors or introducing new monitoring windows is sufficient.

This ensures that the system remains flexible throughout its lifecycle, without the need for a complete redesign every time a product change is made.

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11. Supporting as a partner rather than simply supplying

It is precisely when it comes to complex joining tasks that the difference between a mere component supplier and an experienced partner becomes apparent.

Anyone who takes pressing processes seriously looks not only at the maximum values on the data sheet, but also at the sensor technology, control strategy, holding behaviour, dynamics, mechanical design and subsequent process monitoring.

TOX® addresses this requirement with a systematic approach that combines drive, control, sensor integration and software.

This offers the customer a clear advantage:

He is not just getting a servo press, but a solution that allows processes to be set up, secured and further developed in a technically sound manner.

Flexible servo presses in modern production

12. Conclusion

Flexible servo presses are particularly effective when they not only deliver high forces, but also ensure that processes are carried out stably, monitored and adaptable across a wide range.

That is precisely where the strength of the TOX® system lies:

- wide power ranges
- high dynamism over short distances
- consistent force signals throughout the holding times
- external sensor integration
- fully configurable software within an integrated servo-press system.



Figure 6: Example of a pressing station