Zwick / Roell

Zwick
Materials Testing

Application Note

Successful modernization of Materials Testing Machines

Initial situation and technical specifications

A materials testing machine is made up of many different technologies: mechanical engineering, precision engineering, electrical engineering (electro-mechanics / mechatronics, power electronics, measurement and control electronics, optoelectronics), informatics (hardware and software) and fluid mechanics (hydraulics, pneumatics).

Modernizing, also known as retrofitting, an old testing machine can give you the performance of a modern testing machine at a fraction of the cost of a new one.

However, each machine component ages differently depending on its function. This aging process can be due to material fatigue, wear or various environmental influences or the technology can simply become out-of-date or obsolete. This can cause problems if, for example, a component no longer conforms to the state-of-the-art, no longer works with newer components or can no longer be maintained because there are no spare parts for it.

The mechanical components, such as the load frame for example, age very slowly and can be used for several decades. By contrast, electrical, electronic and informatics components can quickly become obsolete due to the rapid rate of development in these areas of technology.

When a machine component needs updating or renewing, it is important that it is not replaced in isolation, but that all components that interact with it are also checked. All testing machine components work together and, if a machine is to be modernized, it is important to consider the whole picture. For example, when updating the electronics, it is very important to also consider the drive unit. Modernizing the electronics in isolation may be cheaper in the short term, but when lthe drive needs modernizing later you may find the electronics need updating again, or even replacing, resulting in higher costs overall.

EAI 00308

Application Note

Successful modernization of Materials Testing Machines

Why choose Zwick to carry out a modernization?

When modernizing your testing machine, it is important to choose a reliable and competent partner.

The Zwick Roell Group has more than 150 years of experience in manufacturing testing machines and a proven history of service, maintenance, repair and spare parts supply on a global basis through its international support network. Zwick has already modernized thousands of testing machines and based on this experience has built many kits to fit legacy Zwick products and many non Zwick brands of testing system. This allows them to offer a fast and efficient service avoiding unecessary downtime and minimizes 'one-offs' or 'specials' and the resultant support which also tends to be special.

The many different combinations of machines and their components and versions are stored in a database at Zwick and updated at every service, repair or delivery of accessories or spare parts. This enables fast and competent advice and support to users.

Zwick guarantees availability of spare parts for at least 10 years after a machine is no longer in production. To ensure they can support their customers, more than 100,000 different spare parts are kept on stock enabling a fast response when required. For example, integrated circuits obtained from external suppliers are usually only produced for a limited period due to the need to keep up with the state-of-the-art. In order to guarantee service beyond this time, Zwick keeps stocks of such items based on statistical evaluation of their usage in the field.

All components of a modernization carried out by Zwick are comprehensively documented and comply with EC directives, relevant safety standards and regulations as well as rules regarding electromagnetic compatibility.

Zwick has the systems in place to ensure that modernized testing machines perform to the same standards as a new machine, at a fraction of the price, and can be supported around the world.

Worldwide customer support means highly qualified, specially trained and experienced service engineers equipped with state-of-the-art tools and means, ensuring efficient service and customer satisfaction.

Field service team at Zwick headquarters in Ulm, Germany

Fully automatic storage system at Zwick headquarters

Application Note

Successful modernization of Materials Testing Machines

Points to consider when modernizing your testing machine

Zwick's engineers have many years of experience regarding the different components that make up a materials testing machine and how these components age. This gives them a unique understanding of the machine as a whole and how the different components age differently and interact with each other. The modernization team knows exactly what to consider and what to do in each case.

Using the corresponding modernization package, adapted to the different machine types, electro-mechanical, hydraulic or servo-hydraulic testing machines, pendulum impact testers or vibrophores of different design and make are technologically updated and retrofitted to state-of-the-art technology.
Zwick recommends that all electrical and electronic parts are replaced including the drive system in order to fully comply with the latest CE / VDE / EMC and other safety regulations.

The modernization package of a static materials testing machine normally consist of the following components:

- Digital measurement and control electronics
- Testing software *testXpert*® II
- Maintenance-free AC drives
- Proportional or servo-operated valves as well as hydraulic power packs for hydraulic materials testing machines

All these components are fully or in part replaced during a modernization. This depends on the state of the machine to be retrofitted and will be analyzed in detail by the Zwick modernization team.

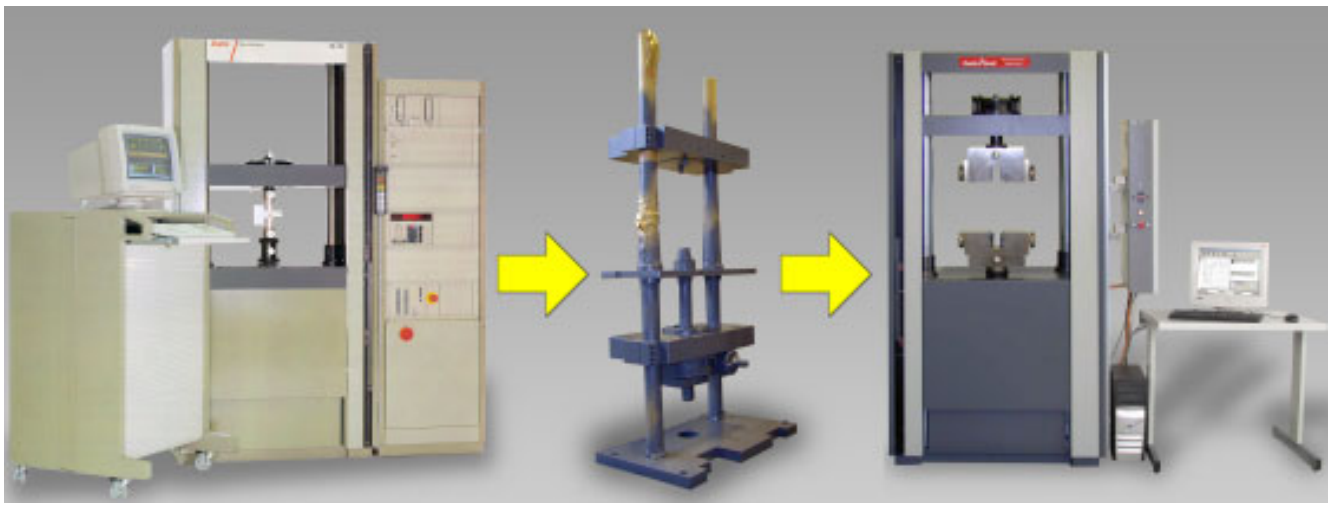
Other components, such as load cells, extensometers and the like will be adapted or build in when necessary or depending on testing requirements. Thus your modernized materials testing machine becomes a completely renewed testing system, upgrades your laboratory decisively and fulfills modern testing tasks.

In the following the different components of Zwick modernization packages for electro-mechanical materials testing machines, their different fields of application and special features will be explained.

The testing machine load frame

The machine frame is designed to be very stiff, robust, and strong in order to cope with testing conditions such as stresses and loads during a test, particularly when a specimen breaks.

Mechanically loaded and moving components such as lead screws and lead screw bearings are, as is usual in mechanical engineering, designed for many decades of use. The actual lifetime of a testing machine frame depends on how it is used, maintained, and environmental conditions.



Step by step: converting the Old into New

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The testing machine drive unit

Most modern testing machine drives operating above a certain load capacity use AC motors instead of DC motors. When modernizing a testing machine it is important to consider replacing older DC motors with AC motors because they offer several advantages:

- AC motors do not use brushes and commutators. This means there is no brush sparking and no associated wear.
- Sinusoidal commutation guarantees jerk-free running at very low speeds which is advantageous for strain controlled testing and testing of sensitive materials.
- AC motors are highly robust. Waste heat from the winding is expelled via the motor housing. For extreme loading a fan can be fitted to blow unfiltered air over the housing. Disk armature DC motors are less robust and require filtered air to be blown into the motor interior and over the armature or the performance specification has to be reduced accordingly
- The permanent magnets used in AC motors have a much greater field strength than the electromagnets used in DC motors. They generate a magnetic field without requiring electrical energy. By mounting them on the motor shaft the motor size is significantly reduced and heat energy and electrical losses are significantly reduced
- AC motors are comparatively small and light, resulting in low armature inertia. This gives them better speed control and makes them more responsive

AC motors are very compact – yet robust and efficient compared to DC motors

- Despite approximately half the weight (and thus also size), nominal power and torque are more than twice as great. Simply put, the ratio between motor weight and power is 1 (AC) to 4 (DC) which means that a DC motor of same power is four times heavier. This helps to reduce laboratory space occupied by the testing system
- The lower current and greater torque offers much higher electrical efficiency thereby saving energy and its associated long term cost
- The thermal time constant means that it will heat up considerably more slowly and thus can stand higher loadings for a longer time.
- The much lower rotor moment of inertia offers high dynamic response and therefore excellent controllability. Compared to DC motors the lower power requirement for acceleration and deceleration is particularly beneficial for cyclic tests.
- The complete modernized testing system can be supported by Zwick

Comparison with data for a DC motor clearly shows the advantages of the AC motor:

Main performance characteristics	DC motor (disc armature)	AC motor (bar armature)
Nominal load P_n	2,0 kW	4,4 kW
Nominal rpm n_n	3.0001/min	3.0001/min
Nominal torque M_n	6,37 Nm	14,5 Nm
Rated current I_n	13,6 A	8,6 A
Rotor moment of inertiat J	23,0 kgcm²	9,5 kgcm²
Torque constant K_{Tms}	0,51 nM/A	1,75 Nm/A
Thermal time constant t_{TH}	1,45 min	60 min
Weight G	25 kg	13,7 kg

Table: Comparison of performance data for a DC and AC motors on a 100 kN testing machine

Application Note

Successful modernization of Materials Testing Machines

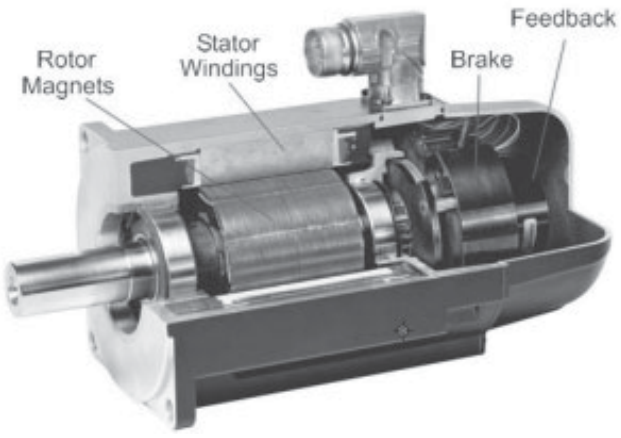
Reduction drives or gearboxes between motor and lead screw drive

AC motors are extremely powerful and relatively small. Using digital position control their torque and speed range is so high that the maximum test load of the load frame can be achieved over the entire speed range and with enough spare for accelerating and braking. Only one reduction drive, usually in the form of a toothed belt drive, is needed which removes the need for multi-stage or manually operated gearboxes.

Drive control electronics

Older DC drives use analog rotational speed control, with the actual speed feedback generated by a tachometer and the set value from a voltage source such as an adjustable rotary potentiometer. These signals are not drift-free and have limited resolution. Over-travel limits or target test stroke positions, set via electro-mechanical switches, are not reached precisely, and are subject to a time-lag dependant on speed and inertia.

With modern AC drives current and rotational speed as well as crosshead position are digitally controlled. The signal from an encoder on the motor shaft serves as actual value. Revolutions are resolved in several thousands of steps. The number of steps is directly proportional to the crosshead travel. The set value can be specified by the testing software as a fixed value or a sequence. The controller comprises a very fast computer which processes actual, set and control signals several hundred times per second in real-time, and can react extremely quickly to the smallest deviation.



If a target position is to be driven to, then the actual and set positions are not simply compared, with braking activated at ‘zero deviation’. The difference is continuously measured and the braking process introduced with a defined delay as soon as the difference reaches a pre-calculated value.

This highly dynamic – yet smooth, intelligent control system is the basis of many applications:

- Drift-free holding of crosshead position with engaged drive, up to maximum test load

- Highly accurate, reproducible movement to several crosshead positions preset by the test program, such as
  - grip-to-grip separation (L_e) which helps the machine operator to reduce set-up time between different tests
  - tests sequences based on defined crosshead positions or real-time events

- Virtual crosshead limit switches to protect grips, tools, or fixtures mounted in the load frame

- Cyclic tests, hysteresis tests, low-frequency alternating load tests, low cycle fatique (LCF) etc. The frequent change of direction demands significantly higher drive performance, as all moving masses from motor to crosshead must be continuously accelerated and decelerated. The low inertia and high load capacity make faster load cycles and/or longer crosshead travel possible, also because the motor can be subjected to higher thermal loading for a longer period and, if necessary, cooled more conveniently

- Tests with very low test speeds and large test loads, such as creep tests, or for load calibrating tests

- Large test-speed range, for example low-cycle fatigue / creep tests, or high speed return after test on high tensile strength specimens with high elongation

- For closed loop stress and strain control where an additional control loop is formed with variables depending on load or elongation. Because it is necessary to react to rapidly changing material behaviour, this is only possible with dynamic and smooth control systems.

Application Note

Successful modernization of Materials Testing Machines

As well as testing material properties Zwick machines are also being used with increasing frequency for functional tests, as they not only generate loads/forces and travels, but can also measure these very accurately and can control them independently. One example is the pressing of bushes or pins into interference holes. Positions must be very accurately and reproducibly driven to whilst the press-in force measured and evaluated as a function of the press-in depth. This is only possible with a position-controlled drive.

Specimen grips and fixtures

For the majority of test tools and fixtures, such as specimen grips, compression and flexure kits, special test devices etc., the same applies as for the machine frame.

Modern specimen grips are only required if simplification of handling or robotic operation, for example via electrically motorized, pneumatic or hydraulic drives, is envisaged, or for updated test requirements with 'new' specimens. Zwick manufactures one of the worlds largest range of specimen grips, tools, and fixtures for every conceivable testing application.

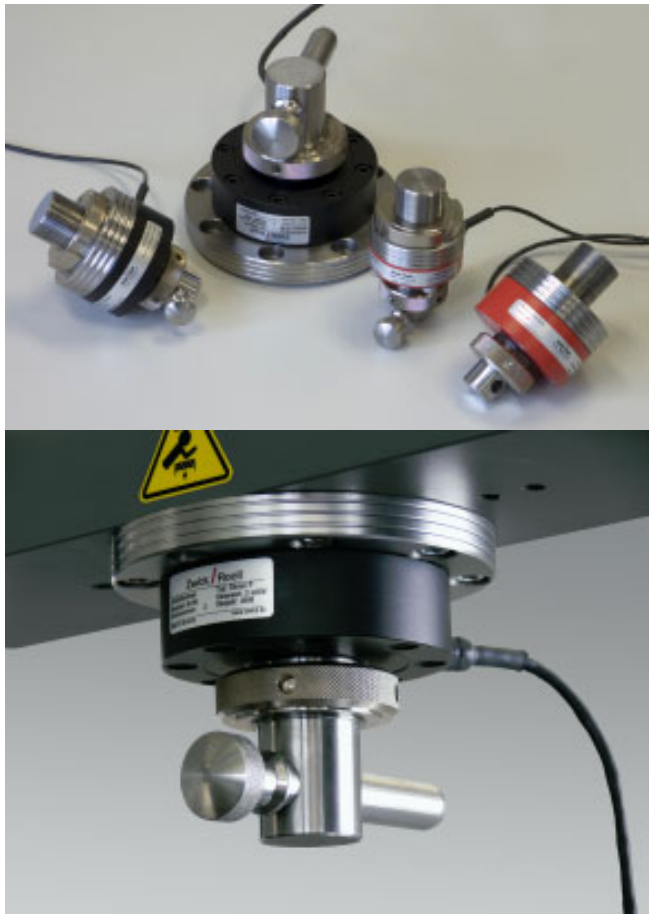
Modernized testing machine with hydraulic grips

Load cells

Strain gage load cells can continue to be used. They only need to be retrofitted with new plug connectors for the new measurement and control electronics.

To use new load cells, mechanical adapters are sometimes needed for connection to the load frame. For most brands of testing machines load cell connectors for specimen grips have not changed for many years.

The strain gaged members of modern load cells and to some extent also the models or designs of strain gages applied to them are less sensitive to parasitic load effects, such as lateral forces or bending moments. This can also be a reason for replacing the load cell.



Modern load cells virtually eliminate side load effects

Application Note

Successful modernization of Materials Testing Machines

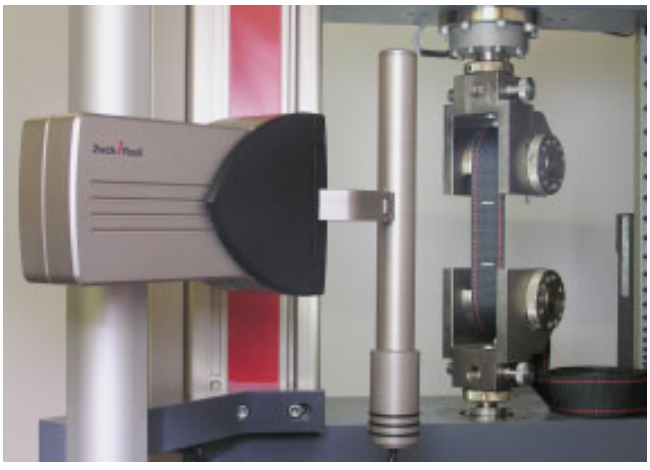
Extensometry

Most existing extensometers can continue to be employed after retrofitting of new connectors.

However, a major benefit to users is that modern high resolution digital or non-contact devices offer advantages in accuracy, higher resolution, or longer measuring range.
Operator influence is significantly reduced as these devices are normally equipped with mechanical drive units which save testing time and improve accuracy and reproducibility of test results by allowing part or full automation.

Zwick offers the widest range of digital extensometers of any testing machine manufacturer.

All of Zwick's extensometers can be used with a modernized machine



Measurement and control electronics *testControl*

The decisive criterion for modernization is the measurement and control technology. Zwick's *testControl* offers users the following unique advantages compared to more traditional systems:

- Very large force and extension measuring range with very high resolution and accuracy without range switching.
- Fast data acquisition with time-synchronized measurement data on all channels
- Automatic identification, adaptation, and protection of measuring sensors including their limit values with zero and sensitivity correction.
- Sensor data can be automatically logged with the test results for traceability of data
- Real-time operating system which can compensate load frame compliance, target strokes, and control sequence events such as change speed at calculated plastic strain during the test.
- Expansion possibilities for up to ten measuring channels.
- Data sampling of 500 Hz for digital sensors such as extensometers and displacement transducers

Instron 100 kN, modernized with *testControl* electronics

Application Note

Successful modernization of Materials Testing Machines

Testing software

Zwick's unique *testXpert*® testing software has been sold more than 15,000 times and is currently available in 9 different languages

Comprehensive application software with hundreds of standard test programs for test applications and test sequences

Three product lines offer:

- Standard test programs for special test standards and targeted at production and routines testing where ease of use, reliability, and automation of test sequences is required.

- Master test programs for research and education organizations, allowing deep and unrestricted access into the test sequence control and data acquisition.

- Graphical Sequence Editor which allows users to build their own test sequences and applications without the need for programming skills. Machine safety functionality according to CE is already integrated and the user only needs to care about test functions such as controlling automatic extensometers, drive sequences and their associated contol parameters, result calculations using built-in or custom formulae, graphical displays of channel data, data input and output.

Standardized testing software program minimizes training, support and update costs

Summary

Zwick offers customers a complete service from consultation and advice regarding the modernization possibilities for their existing electro-mechanical testing systems. Standardized modernization kits to suit most major brands are supplied, and engineering expertise to carry out and support projects anywhere in the world is offered.
After systems have been fully modernized, testing systems have the same functionality as a new machine but at a fraction of the price.

Zwick's unique solution means that customers can further update their systems at a later date in line with changes in testing standards or to add new equipment such as automatic digital extensometers, or even robotic specimen feeding systems.

Zwick is also able to offer a range of modernization packages for other testing equipment including servo-hydraulic, hardness, impact, and creep test machines.

For more details visit www.zwick.com, or to discuss how Zwick can help you to modernize your testing system please contact us at info@zwickroell.eu

Schenck Trebel RME 100, modernized