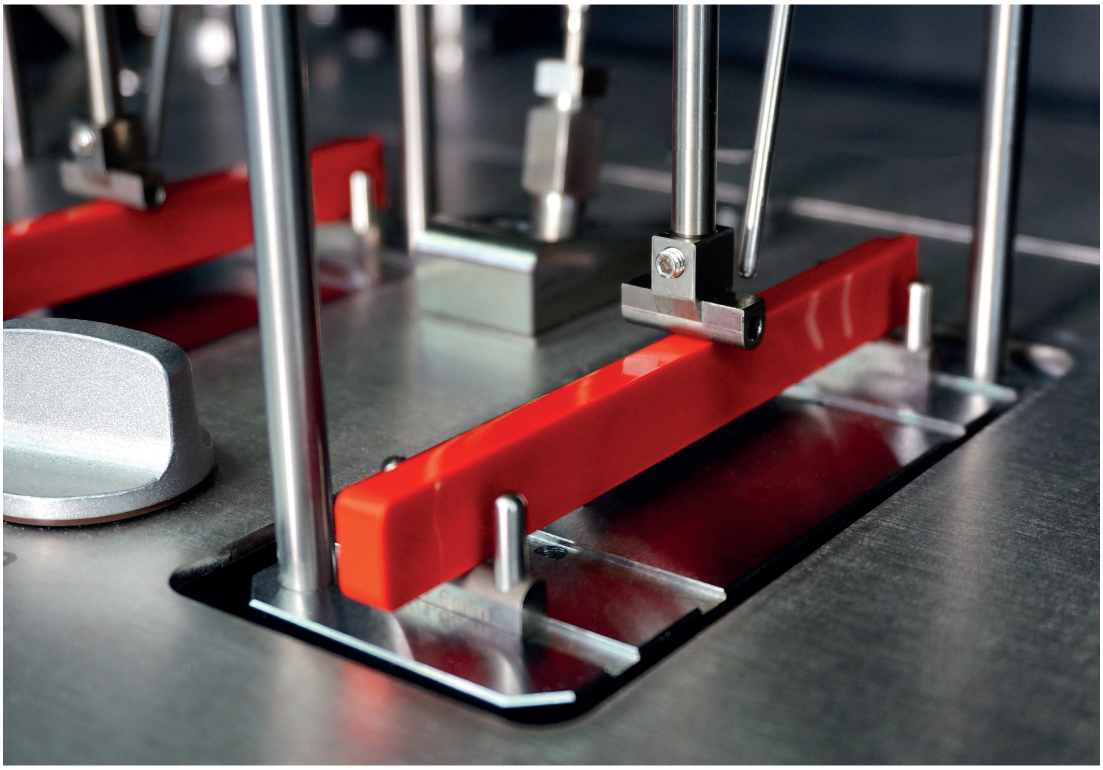

Measuring the heat distortion temperature of a sample. Thermoplastics in particular increasingly lose their stiffness and hardness at higher temperatures.
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High-Precision Mechanical Testing

Material Testing on Plastics

Mechanical testing and material characterization of plastics involve a variety of equipment and machines. The studies extend from simple tensile and pressure testing, through measurement of the heat distortion temperature, to long-term properties and the durability in the finite-life and high-cycle ranges. In addition, impact tests can be used to assess the material behavior at higher deformation rates.

In view of the large variety of polymers that are currently available to manufacturers, it is important to have precise knowledge of the strengths and weaknesses of the individual materials. Thus, the automotive industry focuses on entirely different properties from the medical industry, for example. To be able to make full use of the potential and opportunities offered by plastics, precise knowledge of the material characterization and qualification is therefore essential. The required tests are similarly varied.

Static tests, such as tensile and compression tests, but also flexural tests, are among the most widely performed tests of all. They generate fundamental characteristic values in development and permit extensive conclusions to be drawn about the material behavior of components during quality assurance. Universal testing machines, such as the AllroundLine series from ZwickRoell, thanks to their modular design and an extensive selection of accessories, cover all static test methods. When used with a temperature chamber, tests can be conducted in a wide temperature range from –40 °C to +250 °C. In addition, with up to three test areas in a single test machine, work is flexible without the need for retrofitting. The system configuration builder of the testXpert III test software loads all relevant parameters at the touch of a button, thereby supporting rapid exchange of the preconfigured system configurations.

Hardness is also a basic property of any material. It can give an indication of the material's abrasion resistance and tensile strength. The traditional methods of hardness determination on plastics include, for example, the Rockwell hardness test and ball indentation hardness. ZwickRoell offers an extensive portfolio, tailored to customers' needs, from analog manual devices for determining Shore hardness, through universal hardness-testing machines, to combinations of a hardness measuring head and universal testing machine for instrumented penetration testing. In addition, with the

ZHN Nanoindenter, the hardness of thin layers and small surface areas can be securely and reliably determined.

Stiffness and Hardness at High Temperatures

The maximum service temperature of a plastic is closely linked to its hardness. Thermoplastics, in particular, increasingly lose their stiffness and hardness at higher temperatures. This limit, under comparable conditions, is indicated by two characteristic values: heat distortion temperature and Vicat softening temperature. The behavior of the plastic is measured by constant loading, which, with increasing temperature, leads to increasing deformation of the test specimen in the form of a deflection or the penetration of a needle. Determination of these temperatures follows the standards ISO 306, ASTM D1525, ISO 75 and ASTM D648.

For the Vicat softening temperature (VST), a hardness loss is determined by means of the penetration of a needle under load at increasing temperature. The VST is the temperature at which the needle reaches the predetermined penetration depth. Because of the relatively small test specimen, this method is good for measurements on test specimens removed from components or parts. For measuring the heat distortion temperature (HDT), the loss of stiffness is measured by a three-point bending method. Both methods are used in characterization of molding compounds and belong to the single-point data defined in ISO 10350–1.

Determination of the Heat Distortion Temperature

The new Amsler HDT/Vicat is designed for comfortable testing in research and development, incoming goods inspection and production monitoring. The test machine is designed for determining the heat distortion temperature and Vicat softening temperature and the creep behavior under flexural loading. Depending on the requirements, the device can be equipped with two, four or six measurement stations.

The heat distortion temperature (HDT) is measured according to ISO 75 parts 1 to 3 and ASTM D 648 on thermoplastics, hard rubber and fiber-reinforced and filled thermosets. The determination of the Vicat softening temperature (VST) on thermoplastics follows ISO 306 and ASTM D 1525. Thanks to a digital measurement system, a high accuracy with uniform calibration for HDT and Vicat is reached. The very easy operation is supported by the automatic test sequence and by the fact that the weights to be put on are automatically determined and displayed. Enhanced with the testXpert III software, powerful capabilities are available, such as measurement and control graphics, results determination, data storage and export functions.

The heat transfer to the sample body plays an important role in this test method. The classical method therefore operates with a heat transfer fluid – usually a silicone oil – and thus achieves the test results with a high degree of comparison accuracy. ZwickRoell offers an alternative method – with an oil-free measurement principle – in the form of its Vicat Dry model for determining the softening temperature.

Permanent and Cyclic Loads

A creep test serves for evaluating the long-term behavior of plastics and is particularly important for products that are under permanent loading, such as pipes, seals and bearing components. It is conventional to use tensile, compression and flexural tests; the tests often take several weeks or even months. Purely mechanical loading is often accompanied by thermal loading, a fact »

The Amsler HDT/Vicat test device is designed for determining the heat distortion and Vicat softening temperature and the creep behavior under flexural loading.

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Pendulum impact testers are used, e.g., for assessing the deformation of the plastic even at high velocities. © ZwickRoell

that is taken account of by the Kappa Multistation with an integrated temperature chamber (-40 to +250 °C). The creep test machine was specially developed for the analysis of the creep behavior of plastics and polymer materials. On up to six individually controlled test axes, creep tests up to 10 kN can be freely combined and performed under normal conditions or temperature. Precise strain measurements are performed by means of the videoXtens range of optical extensometers. Mounted behind the temperature chambers, they allow an unobstructed view of all samples via the view window without influencing the tests.

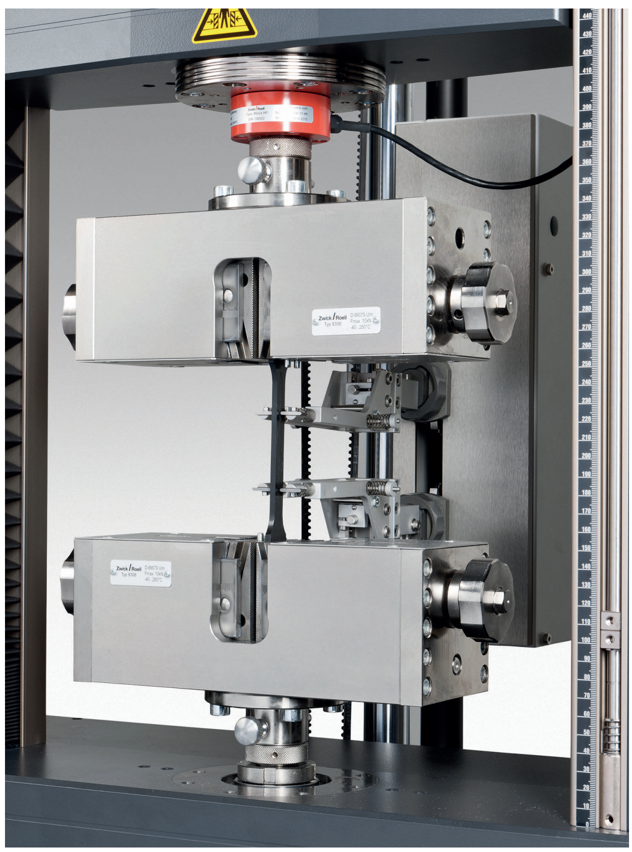
While the long-term behavior under static load is tested, dynamic tests are necessary to determine the durability in the finite-life and high-cycle ranges. Components subject to a cyclic load withstand lower stress values in the long term than those under static loading – they fail due to material fatigue. A good option is an electrodynamic test machine of the LTM series, which is available with forces between 1 and 10 kN. Due to the high velocity range, they can be used in quasistatic tests through to dynamic fatigue tests with maximum 120 Hz test frequency (depending on the model). The oil-free drive offers a whole range of advantages, from simple commissioning of the test machine – which does not require a connection for either oil or water – to low energy consumption and low noise emissions. Both have a noticeably positive effect, in particular in relatively long tests.

To assess the deformation of the plastic even at high speeds, pendulum impact testers, drop-weight testers or high-frequency testing machines are used. Instrumented pendulum impact testers with force sensor and rapid data acquisition permit further data, apart from the impact energy values, to be recorded and evaluated. The same applies to the use of instrumented drop-weight testers. For example, in the puncture test, they record complete force-travel graphs, from which characteristic force points and the absorbed impact energy can be calculated.

The high-frequency test machines with hydraulic drive, which are always instrumented, generate test velocities of up to 20 m/s. They can be versatilely used for high-speed tensile tests, puncture and flexure tests and cover the methods of the pendulum impact testers and instrumented drop-weight testers. Thanks to the high surplus energy and special control system, they allow almost constant test velocities during testing.

Hardware and Software Complemented by Robots

The ZwickRoell portfolio covers everything necessary for equipping a test laboratory in the field of plastics technology – from extrusion plastometers, through hardness testers, Charpy impact, tensile or flexural tests, through to creep and fatigue tests. The unified test software ensures an intuitive and workflow-oriented operating concept, which significantly reduces the familiarization phase and input errors. In conjunction with the roboTest N lightweight robot, many of the above-mentioned tests can even be automated and carried out in series. ■



Tensile tests provide information about the material behavior of plastics. © ZwickRoell