Single Fibre Testers
VIBROMAT, FAFEGRAFH, FAVIGRAFH and FAVIMAT ROBOT

Testing and evaluation of a wide range of fibre properties are essential for quality control purposes in man-made fibre production and for assessing the processability of fibres in spinning. Usually, these tests are carried out on single fibres. Here, typical testing methods are the static tensile test, linear density (fineness) measurement and measurement of crimp extension, crimp stability as well as number of crimps.

VIBROMAT ME

The VIBROMAT ME is a measuring instrument to automatically determine the linear density of single fibres using the vibration method, e.g. according to ASTM D 1577. With this testing method, the resonance frequency of the sample is measured at constant gauge length and known pre-tension; the data obtained is then used for calculating the linear density. To simplify matters, uniform mass distribution along the fibre and fibre circular cross section are assumed. The influence of bending stiffness (elasticity modulus) is not taken into account. The following formula can then be applied to calculate the linear density:

\[
T_t = \frac{F_V}{4 \cdot f^2 \cdot L^2}
\]

with:
- \(T_t\) = linear density in dtex
- \(F_V\) = pre-tensioning weight in mg
- \(f\) = resonance frequency in Hz
- \(L\) = test section length in mm
With the VIBROMAT ME, the resonance frequency of the fibre can be measured using two different methods. In both cases, transverse vibrations of the fibre, initiated by an acoustic transducer, are recorded using an opto-electronic sensor.

With the frequency interval method, the excitation vibration spans over a frequency range. The excitation frequency which gives rise to the maximum vibration amplitude is the fibre resonance frequency. The frequency interval method enables fibre linear density measurements down to a minimum of 0.1 dtex to be made.

In contrast, with the impulse method, fibre vibration is initiated through a single impulse, with subsequent vibration at the resonance frequency in the form of a damped oscillation. The impulse method has the advantage of a significantly shorter measuring time. It is suitable for fibres down to a minimum of approx. 2 dtex.

Selection of the two methods can either be made automatically, based on the resonance curve quality of a fibre, or can be specified by the operator.

**Technical data**

Measuring range: 0.1 – 200 dtex.
Test section length: 20 mm.
Mains supply: 220 V, 50 (60) Hz, current requirement approx. 0.5 A.
Lacquer finish: RAL 7004/7035.
Dimensions, weight: Height 610 mm, width 305 mm, depth 540 mm, approx. 37 kg.
**FAFEGRAF HR and FAFEGRAPH ME**

**Tensile testing** of single fibres represents one of the most important quality control testing methods in chemical fibre production. In addition to the *(linear density-related)* **breaking force** and **breaking elongation**, other parameters such as **modulus**, **intermediate values of the force/elongation curve**, e.g. force values at specified elongations, **work to rupture** or **characteristic values for elastic- and plastic deformations** can be obtained.

An additional important value determined through tensile tests is the mechanical **crimp properties** of a fibre, which are characterized by the following parameters: crimp elongation, crimp removal force and crimp stability.

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**Crimp test**

**Crimp stability test**
Tensile tests conducted within the range where crimp is removed from the fibre require a **highly sensitive force measuring system** that also enables sufficient measurement accuracy for tensile forces within a range of a few mg. The FAFEGRAFH HR, as a consequence, is equipped with a compensating force measuring system developed by Textechno; its application for tensile testing equipment is novel. In addition to having an extremely high resolution of 0.0001 cN for a measuring range of 220 cN and full automatic calibration, the system is characterized by high stability against external vibrations and by the fixed position of the measuring element over the entire force measuring range. As a result, errors relating to gauge length and elongation measurements, which occur with conventional measuring systems due to increasing deformation of the measuring element with increasing load, are eliminated with the FAFEGRAFH HR.

For crimp tests in particular, where there is a need to avoid any external influences on the measurement, e.g. breath of the operator, the FAFEGRAFH HR is equipped with a recessed testing section that can be isolated by a motor-driven sliding glass window.

The actual test section comprises the measuring- and draw-off clamps, which open and close automatically. The clamp jaws are tightened by spiral springs and the clamping force can be steplessly and reproducibly adjusted over a wide range. The gauge length between clamps can be varied between 5 and 100 mm.

**Tensile tests in water** or other liquid media are also possible (optional).
Push button keys situated on the front panel of the tester can address all the functions of the testing instrument. Alternatively, the equipment can also be operated using a single push button key or foot switch.

Combining the FAFEGRAPH HR with the single fibre linear density tester VIBROMAT ME is particularly advantageous. Each fibre is initially subjected to a linear density test and then to a tensile test. Here, the TESTCONTROL computer system, shared by both devices, supplies a summary of the results for linear density-, tensile and crimp tests, as well as the resultant force values related to linear density.
The construction of the FAFEGRAPH ME is to a large extent identical to the FAFEGRAPH HR. The ME model is, however, equipped with a conventional force measuring system for measuring ranges up to 10 000 cN and with pneumatically closing single fibre clamps.

For carrying out tensile tests on fibre bundles on the FAFEGRAPH ME, the single-fibre clamps can be replaced by mountings for fibre bundle clamps.

Testing methods

- Static tensile testing, cyclic load testing, creep- and relaxation trials on single fibres;
- Measurement of crimp properties (HR model only).

System components

Test section:
- 2 single fibre clamps, closing either through spring pressure (HR model) or pneumatically (ME model);
- Continuously adjustable gauge length 5 – 100 mm;
- Draw-off clamp speed 0.1 – 100 mm/min, return speed 300 mm/min, max. travel of draw-off clamp 100 mm;
- Optional use of special clamps for tensile tests on fibre bundles (ME only);
- Optional automatic wet testing device.

Measuring systems:
- Force measuring device, designed as a self-compensating, path-free measuring system, resolution 0.0001 cN, measuring range 220 cN (HR);
- Inductive force measuring device with easily exchangeable force transducers, max. 100 N;
- Elongation measuring device with resolver, resolution 0.1 µm.

TESTCONTROL:
- PC system for controlling the test processes and for the evaluation of the measured data, connected via serial interface;
- Input of all parameters for testing and measured data evaluation on the PC, saving of selected parameter sets of test conditions under code words;
- PC easily integrated into any network type.

Further technical data

Mains supply:
- 220 V, 50 (60) Hz, current requirement approx. 1.5 A.

Compressed air supply:
- 5 bar, 10 l/min.

Lacquer finish:
- RAL 7004/7035.

Dimensions, weight:
- Height 600 mm, width 600 mm, depth 540 mm, approx. 95 kg.
FAVIGRAPH

In synthetic staple fibre quality control, VIBROMAT and FAFEGRAHH tests are usually carried out at the same time with the two testing instruments arranged side by side. This initiated the development of the FAVIGRAPH, which combines both linear density measurements and tensile tests into one test equipment.

Here, the linear density measuring head, which is based on the VIBROMAT ME technology, is situated adjacent to the tensile test section incorporating the components of the FAFEGRAHH ME. The innovative characteristic of the FAVIGRAPH is a transfer clamp between the two measuring systems, into which the appropriately pre-tensioned fibre is manually loaded. At the start of the test, the transfer clamp is positioned above the linear density measuring head. First, the linear density of the fibre is determined. Thereafter, the transfer clamp turns to the tensile test section and places the fibre into the measuring and draw-off clamp. During the tensile test, it is possible to already insert the next fibre into the linear density measuring head.

As a consequence, continuous parallel operation of both systems is ensured. With corresponding short fibre breakage times, cycle times of 15 seconds are easily achieved resulting in a test output of 240 fibres per hour.
Moreover, a special advantage of the FAVIGRAPH is that the operator handles the fibre only once when introducing it into the transfer clamp at the linear density measuring head. Compared to conventional systems, where two independent testing instruments necessitate separate introduction of each fibre, the FAVIGRAPH-technology signifies a substantial reduction in both work input and possible fibre damage.
FAVIMAT ROBOT

The design of the FAVIMAT takes into account needs to combine single fibre linear density measurements and tensile tests with different crimp test methods into a single testing instrument, enabling all of these tests to be carried out on the same fibre section. Transferring the fibre from one testing device to another is, therefore, no longer necessary. Similar to the advantages of the FAVIGRAPH, this results in an even more significant reduction in both operator input and expenditure as well as a reduction in possible fibre damage when compared to multiple measurements carried out on alternative independent devices.

The construction of the FAVIMAT is based on the single fibre tensile tester FAFEGRAPH HR. It incorporates, however, two additional measuring systems located in the tensile testing section. The highly sensitive load cell enables accurate adjustment of specified pre-tensions, as well as the measurement of extremely low tensile forces when determining fibre crimp properties. To ensure highest measuring accuracy, computer-aided calibration of all measuring systems can be carried out automatically.
The FAVIMAT testing methods

**Linear density test**

The measurement is based on the vibration method and in principle corresponds to the technology of the frequency interval method with acoustic excitation of fibre vibration and opto-electronic recording of the resonant frequency as applied to the VIBROMAT ME.

**Static tensile test and examination of mechanical crimp properties**

The FAVIMAT is identical to the FAFEGRAPH HR regarding the carrying out of these testing methods, determination of measurement results and the efficiency of the measuring systems.

**Determination of crimp geometry**

A further measuring system with opto-electronic sensor integrated in the FAVIMAT enables the creation of a digital image of the crimped fibre, which is held between the two clamps, and the subsequent evaluation of the crimp geometry regarding crimp number and crimp amplitude. As applicable to mechanical crimp properties, size, shape and regularity of the crimp geometry supply important information regarding the crimping process during fibre production, as well as the further processing of the fibres and the properties that can be expected from the intermediate- and finished products.

**Test sequence**

Depending on the task in hand, either one of the four tests or a combination of two, three or four tests can be carried out on a single clamped fibre.
The ROBOT and AIROBOT automatic fibre feed units

Especially when the crimp stability test is included, testing of a single fibre may take several minutes, depending on selected loading and relaxation times. As a consequence, the operator must wait accordingly before the next test can be initiated. This clearly demonstrates the advantages of an automatic supply of test specimens.

For this purpose the automatic unit ROBOT can be added to the FAVIMAT. ROBOT comprises a sample storage unit and a transfer clamp, the latter for transferring the single fibre from the storage unit to the test section, and a suction system for removing the waste fibres after each test. The sample storage unit contains up to 18 magazines, each of which can accommodate 25 individual fibres. Therefore, the total capacity of the unit amounts to 450 fibres. Depending on the test requirements, the fibres are suspended in the magazines using tongs-shaped pre-tensioning weights, e.g. equating to the standard pre-loading for tensile tests, or paperweights for crimp tests. The magazines are transported in the sample storage unit via a paternoster-type system. During a running test series, empty storage magazines can be removed and reloaded.

The AIROBOT is a variant of the ROBOT automatic fibre feed unit. Here, the fibres are loaded pneumatically into the magazine in a semi-automatic loading unit. When being transferred from the sample storage unit into the FAVIMAT test section, the fibres are slightly pre-tensioned by a suction device. The AIROBOT does not require pre-tensioning weights, resulting in a further substantial increase in test preparation efficiencies.
FAVIMAT AIROBOT
Efficient testing with FAVIMAT ROBOT

The time required for testing a single fibre on the FAVIMAT, including feeding and removal of the fibre, amounts to approx. 35 seconds (force-elongation test with 20 seconds breaking time and linear density test). The full programme, including crimp stability examination, has a duration of approx. 4 min. Operator time required, therefore, amounts to between approx. 4.5 and 30 hours for 450 fibres when the FAVIMAT is used without automatic sample feed. During conventional testing with separate testing instruments and visual crimp counting, the overall testing time may be even substantially longer.

When FAVIMAT and ROBOT are combined, the work of the operator is reduced to introducing the fibres into the storage magazine and, where applicable, attaching the pre-tensioning weights. After appropriate operator training, it can be assumed that the loading of 450 fibres into the storage magazines will require approx. 80 min. In case of the AIROBOT this time is even further reduced to about 45 min. In the extreme case, this corresponds to a reduction in working time in excess of over approx. 95%. When comparing the above figures, the enormous rationalization effect of the FAVIMAT ROBOT is clearly evident, which results from the combination of different test methods into a single instrument, together with automated sample feed and -disposal and the large capacity of the sample storage unit.

Testing methods

– Measurement of linear density of single fibres with the vibration method;
– Static tensile test, cyclic load testing, creep- and relaxation trials on single fibres;
– Measurement of mechanical crimp properties,
– Crimp number and -geometry measurement.
System components

Test section:
- 2 single fibre clamps, closure through spring pressure;
- Continuously adjustable gauge length 5 – 100 mm;
- Draw-off clamp speed 0.1 – 100 mm/min, return speed 300 mm/min, max. travel of draw-off clamp 100 mm;
- Additional vertically movable measuring head that automatically swings into the test section, comprising two measuring systems for the measurement of linear density and the determination of crimp geometry.

Measuring systems:
- Force measuring device, designed as a self-compensating, path-free measuring system, resolution 0.0001 cN, measuring range 220 cN, other ranges available on request;
- Elongation measuring device with resolver, resolution 0.1 µm;
- Linear density measuring system with acoustic initiation of the fibre vibration and opto-electronic recording of the resonance frequency;
- Opto-electronic measuring system for digital recording of the fibre geometry.

ROBOT:
- Fibre sample storage unit for a maximum of 18 magazines, each with a 25 single fibres capacity;
- Transfer clamp ROBOT to FAVIMAT;
- Suction device to remove fibre residues from the clamps;
- Loading unit for fibre introduction into the magazine with pre-tensioning weights (ROBOT) or pneumatics (AIROBOT).

TESTCONTROL:
- As described for FAFEGRAFH HR/ME.

Further technical data

Mains supply:
220 V, 50 (60) Hz, current requirement approx. 1.5 A.

Compressed air supply:
6 bar, 10 l/min.

Lacquer finish:
RAL 7004/7035.

Dimensions, weight:
Height 600 mm, width 600 mm, depth 540 mm, approx. 102 kg (FAVIMAT);
Height 510 mm, width 1220 mm, depth 650 mm, approx. 94 kg (ROBOT).

The above technical contents can be subject to changes by Textechno