PolyLab® System
Torque Rheometer, Extruders, Mixers

Thermo Haake
PolyLab® System – The Complete System

The PolyLab System
In The Application

The complexity of polymers and their blends is subject to continuous development – this is also true of measurement technology.

- Flow and compounding behavior
- Critical processing parameters of temperature, pressure, torque and viscosity

Critical processing parameters of temperature, pressure, torque and viscosity are becoming more important.

PolyLab System is the innovative, market-oriented continued development of the Thermo Haake Rheocord product range which fully meets these requirements.

In Research...

One has to determine the interaction of his additives in new formulations

- New UV stabilizers for the automobile or construction industry
- Polymer additives to starch for biodegradable packaging materials
- Polymer-based ceramics for high-performance injection molded parts

In Quality Control...

One has to carry out tests throughout all stages of processing like:

- Viscosity
- Homogeneity
- Additive dispersion

After all, your customer expects a constant level of product quality. Torque rheometers are used to carry out these tests under processing conditions in the laboratory – requiring only small sample volume. They are designed to meet the highest standards with regards to accuracy, handling and reproducibility, for determining fast and reliable test results. Furthermore the flexibility and application oriented system solutions are becoming more important.

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Master And Slave Share The Intelligence

The PolyLab System consists of the Rheocord torque rheometer which includes all functionality for driving and controlling the measuring sensors. It is the control center for the external PC as well as the other system components: “The Master!”

Intelligent measuring sensors (Slaves) such as measuring extruders and mixers determine the application. They are equipped with measuring and control technology according to the specific application and deliver the necessary data to the Master via a measuring bus system. This shared responsibility relieves the system, so more data can be safely transported on this data highway and new applications can be introduced easily. This flexibility means that the test setup can be adapted to exactly match the required application while ensuring that your system is ready for new applications in the future.
The PolyLab System

The functionally oriented design particularly emphasizes the integration of the base unit and the measuring sensors to form a complete system which has been realized within an ergonomic working environment.

PolyLab System – Born From Experience

Thermo Haake can look back on decades of experience in the field of rheological measurements. The PolyLab System has been designed on this basis together with experienced Thermo Haake customers. It is a product which reflects Thermo Haake’s reputation for application-related solutions.

Safety And Comfort

PLUG and PLAY is the concept. Mobile mixer and extruder sensors mean easy and safe unit handling in the laboratory. Once a measuring sensor has been docked on to the base unit, the Rheocord automatically detects the configuration and all unit specific limits and characteristic values are set accordingly. The measuring ranges of the sensors are also automatically adopted for measurement and calibration as well as the test setup visualization and the user interface. Manual pre-testing as well as process optimization are remote controlled by the user from the position where he or she has the best overview of the process.

Welcoming Thermo Haake as your partner in rheometry means:

- Working out solutions together with our specialists
- Support for installations and software updates
- Advice and counseling and a reliable mobile service support

For further information ask for our detailed data sheets or speak directly to our specialists.
Rheocord® – The Base Unit

**Rheocord – one base unit for all applications**

The Rheocord base unit contains all the parts of a torque rheometer which are required for driving the measuring sensors and measuring the resulting torque.

Interfaces enable communication with:
- the control and evaluation module
- the remote control
- the measuring sensors
- external devices
- networks

The flexibility of the measuring bus technology means that only this one unit is required for all current and future applications. Invest in the future!

This guarantees you:
- special solutions for today’s problems
- the option of remaining open for tomorrow’s new application

**The Technology**

A new modern control concept drives the measuring sensors enabling operation at the optimum drive working point at any time. This results in characteristic lines which meet the highest requirements of extreme applications such as high torque and/or high speed. Torque measurement is carried out via a direct coupled torque measuring cell with an integrated amplifier developed specially for the Rheocord.

This ensures the highest level of measuring accuracy and fault safety for your application. All standard applications are covered with the selected measuring accuracy class. However, if you need an especially high resolution in the extreme application limit area, we can supply you with interchangeable, coded torque sensors necessary for this purpose. The drive control and the transfer of the measuring data is carried out via an MS-Windows™ user interface with a real time operating system and a field bus data transfer line. This is the main prerequisite for safe data communication and guarantees the required data security.

Apart from the interfaces for the field bus and the PC, three RS232C and two analog I/O interfaces are available as standard for the purpose of connecting up to external devices or networks.
Comprehensive System Safety

System safety means safety for the user and the instrument as well as data integrity. This system safety is built into the Rheocord with its control and monitoring modules due to:

- complete safeguarding of all rotating parts
- safety cut-off function if rotating parts are exposed
- internal motor temperature monitoring with cut-off warning and cut-off
- torque limit cut-off for the drive unit and measuring sensors
- real-time operating system for data security
- real-time fault handling - causes the system to react promptly and in a defined way to alarm signals

on-line data storage which enables the intermediate storage of your measuring data at any time

user defined start conditions which guarantee:
- System safety due to e.g. the maintenance of temperature start conditions
- a high degree of reproducibility
- an automatic test procedure
- easy-fit coupling and mechanical safety locking mechanism which ensure:
  - simple handling
  - quick preparation times

Comfort And Operation...

...begins with setting up the unit and ends with cleaning. In this respect, the Rheocord and its operating elements are designed to offer optimum working efficiency in the laboratory.

Once you have docked on the measuring sensor, the control module automatically recognizes the respective configuration. This is displayed on screen and the operator is then prompted through the further configuration of the measurement. The processing conditions are reached quickly due to the self-optimizing temperature control feature. The optimum operating point for subsequent switching to programmed operation can be set “on location” via the remote control. Pre-defined start conditions ensure that no limit values are exceeded. Once these conditions are fulfilled, the measurement is started automatically. After the measuring program has terminated, the unit switches itself back to the user-defined status. Cleaning can be carried out after the automatic data storage procedure.

Cleaning tools can be located close at hand and the cleaning process can be started via the remote control.

- displaying fault messages on screen at all times even if the measurement is being carried out in the background

What do you do while the test is running?

You can evaluate and document the previous measurement parallel to running the current measurement (Fig.1) – our system features genuine multitasking with regard to the soft- and hardware!

You can also prepare a second measuring sensor for the next docking maneuver parallel to the current meas

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Safety Specifications

According to the laboratory instrument standard EN61010 T1 and T2.1.

- Safety warnings and cut-offs for:
  - Motor
  - Torque
  - Control temperature
  - Melt temperature
  - Melt pressure
  - Speed

- Electromagnetic compatibility according to:
  - EN50081
  - EN50082 T2
Rheomix® / Rheomex® – The Intelligent Measuring Sensors

Rheomix & Rheomix – The Application Specialists

Thermo Haake offers a comprehensive program of measuring extruders and mixers which can be attached to the Rheocord base unit. These measuring sensors determine the usage of the PolyLab system for your application. Typical applications in the polymer processing, foodstuffs and ceramics industries include:

- Determination of the processing behavior
- Evaluating processability
- Formulation development
- Compounding
- Producing small profiles and films for further testing
- Rheological testing

Every measuring sensor contains the necessary measuring, control and monitoring technology for the respective application. Rheomex and Rheomix control the data administration as well as the communication with the master unit via the data highway. All measuring sensors are coded so that the master unit automatically senses which unit is connected. The measuring sensor automatically informs the base unit and thus the operator of the configuration i.e. the number and position of the temperature control zones and measuring ports, unit-specific limit values as well as the possible sensor options. The connected pressure sensors are once again independently coded.

A new concept simplifies handling in the laboratory and enables secure operation. This is characterized by:

- Mobile measuring sensors – avoid the necessity of handling of heavy and hot parts
- Integrated heating and cooling circuits – reduce the number of plug connections and thus the danger of making incorrect connections
- Several peripheral units such as feeding and post-extrusion units are computer controllable – meaning better reproducibility and documentation

Rheomix – Exchangeable Mixer Sensors

Mixer sensors are used to test processes such as the mixing, compounding and plastifying of polymers, chemicals, ceramics and pigments under production-style conditions. The PolyLab System used together with the Rheomix mixer sensor produces rheograms from which production-related information can be derived such as:

- Dynamic viscosity depending on the shear load
- Melt behavior in the extruder
- The influence of additives
- Temperature and shear load behavior

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Mixers used for standard applications enable the testing of highly viscous substances such as thermoplastics, thermosets and rubbers. The electric heating also enables the measuring of high temperature plastics up to 450 °C. They are additionally equipped with:

- Exchangeable rotors
- 3-piece measuring chambers
- Compressed air cooling

The model equipped with a larger chamber volume is also suited for producing small batches for further testing.

If special demands are made on the units when measuring your products, Thermo Haake can supply you with mixer sensors and accessories which can be individually adapted to suit the respective conditions such as:

- Liquid temperature control
- Special surface finishing such as wear protection against abrasion or chemically aggressive materials
- Conical measuring chamber for hardening materials
- Pneumatic feeding devices
- Gas volume sensors for the quantification of propellants during the plastification phase
Rheomex – Specialized Extruder Sensors

The extruder sensors of the Rheomex range enable the determination of rheological variables as well as the examination of processing characteristics and the production of polymer samples for further analysis. The extruders are supplied with measuring ports for melt temperature and pressure for evaluating the processing parameters along the extruder barrel and the subsequent measuring or profile dies. The Thermo Haake Postex system ensures the defined continued transport of the extruded material after it has left the die. Both single and twin-screw extruders are available. Typical applications include:

- extruding PVC compounds for a variety of profiles
- film-blowing LDPE and HDPE films
- compounding master batches
- feeding in additives and venting volatile components

A variety of different screw geometries are available to guarantee the optimum adaptation of extruder process to the application. For example:

- standard screws with compression ratios of 1:1, 2:1, 3:1, 4:1 and 5:1
- venting and mixing screws
- wear-protected screws
- corrosion-resistant screws

A selection of feeding devices ensures the problem-free handling of pourable, powdery, sticky and pasty materials.

### The Rheomex Family

<table>
<thead>
<tr>
<th>Model</th>
<th>Description</th>
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| R102  | For temperatures up to 450 °C  
1 heating/cooling zone  
Pressure up to 700 bar  
D = 19.05 mm, L/D = 10 |
| R104  | For temperatures up to 250 °C  
1 heating/cooling zone  
Pressure up to 700 bar  
D = 19.05 mm, L/D = 10 with roll feeder for rubber strips |
| R202  | For temperatures up to 450 °C  
2 heating/cooling zones  
Pressure up to 700 bar  
D = 19.05 mm, L/D = 20 for:  
thermoplastics, thermoplastic ceramics |
| R203  | For temperatures up to 250 °C  
2 heating/cooling zones  
Pressure up to 700 bar  
D = 19.05 mm, L/D = 20 with roll feeder for rubber strips |
| R252/254 | For temperatures up to 450 °C  
3 heating/cooling zones  
Pressure up to 700 bar  
D = 19.05 mm, L/D = 25 for:  
thermoplastics, venting optional |
| R302  | For temperatures up to 450 °C  
4 heating/cooling zones  
Pressure up to 700 bar  
D = 19.05 mm, L/D = 30 for:  
extended foam applications |
| CTW100 | Conical twin screw extruder  
for temperatures up to 450 °C  
3 heating/cooling zones  
Pressure up to 700 bar  
D = 31.80/20 mm, L = 300 mm  
for continuous compounding |
| PTW25 | Parallel twin screw extruder  
for temperatures up to 450 °C  
Pressure up to 500 (150) bar  
D = 25, L/D = 18:36 for:  
continuous compounding |
Dies & Postex For Extrusion-Related Applications

Testing At Conditions Close To Actual Production

Dies and post-extrusion units are used in addition to extruders for testing the rheological characteristics and processability of polymers and for producing test samples in the laboratories.

Dies enable the defined geometries for profiles, films or rheological measurements. The post-extrusion units (Thermo Haake Postex units for short) can transport the extruded material forward in a defined manner and prepare it for further tests.

Both dies and Postex units differ scarcely in design from their larger-scale “big brothers”. Testing at conditions which approximate actual production is guaranteed. Integrated measuring technology increases the application possibilities in the laboratory.

Measuring Dies Usage In Laboratory Applications

Measuring dies create profiles of a defined geometry. Temperature and pressure measurements along the extruder barrel and die enable the accurate definition of melt conditions. The precise monitoring and control of the desired processing conditions is thus possible. The flow geometries take the behavior of different polymer types during extrusion into consideration.

A variety of dies are available for the Rheomex range of Thermo Haake extruders for:

- blown films
- flat films
- pellets
- pipes
- fibers
- coated wires
- screen life tests

The PolyLab System can be transformed into a powerful extrusion capillary rheometer when used together with capillary dies. Rheological data such as shear stress and viscosity functions can be evaluated. These are of paramount importance for the design of injection molds.

Thermo Haake utilize 3D-CAD in all areas of Product development.
**Postex = Post-Extrusion Units**

The handling of the often hot and still formable extruded material is an important part of extrusion testing which cannot be neglected. It influences the material characteristics and surface finish to a great extent. These tasks are carried out by the Postex systems developed by Thermo Haake to ensure that your requirements with respect to the extruded material are fulfilled.

Apart from the defined taking off and preparation of extrudate for further analysis, they also enable the laboratory and processing technician to carry out tests in conditions similar to those experienced during production. The production of small batches of “finished products” is a frequent application for the Thermo Haake Postex systems, especially when alterations to the formulation and product processing are to be evaluated.

The Postex family consists of:

- the blown film take-off: for the defined cooling and taking off of blown films
- the sheet, tape and ribbon take-off: for the smoothing, cooling and taking off of flat films
- the wire coating take-off: for the joining up of wires and the melt for the cooling, taking off and coiling up of coated cables
- the water bath/pelletizer: for the cooling and pelletizing of one or several strands of extruded material
- conveyor belt: for the defined taking off of extruded profiles

The optical testing systems and the melt pump are the specialties of the Postex family.

- the fish-eye tester OQT512: integrated within the blown film take-off or sheet, tape and ribbon take-off for testing films for fish-eyes and black spots
- the die swell tester: for determining the die swell giving relative information on the elastic characteristics of the extruded material
- the melt pump: for improving the melt pressure constancy before the extruded material enters the die

**The PolyLab System: Tests With Extruder Sensors, Dies And Postex Units**

The PolyLab System is ideally suited for tests carried out under conditions similar to actual production with laboratory-scale extrusion systems. A few examples are listed below:

- the testing of the pigment dispersal of PVC dry blends with the twin screw extruder Rheomex CTW100, a sheet die and the sheet, tape and ribbon take-off
- the testing of the extrusion behavior of SBR mixtures with the single screw extruder Rheomex 104, the Garvey die and the conveyor belt according to ASTM D2230
- the testing for transparency and fish-eyes with the single screw extruder 252, the blown film die and blown film take off and the OQT512
Rheometry – Practical Application Examples

Rheometry is becoming more and more important in the plastics industry, both in the areas of development and processing. Injection molding technology, where very high shear rates occur at the injection channels and low shear rates are prevalent during the final filling out of the form, is just one example of the wide range. The quality control department must assure that the polymers supplied do not deviate from the standard during processing in the extruder.

Thermo Haake can supply a range of measuring systems for the rheological testing of your polymers:

- the PolyLab System used together with a Rheomix Extruder sensor and capillary dies as an extrusion capillary rheometer
- the PolyLab System used together with a Rheomix mixer sensor for relative rheological measurements
- the RheoStress and Rotovisco rotational rheometers equipped with plate/plate or cone/plate sensor systems

**Examples from the Thermo Haake Rheocord laboratory**

**Example 1: Determining a PE reference curve**

The reference curve illustrates the viscosity values of a polymer measured over several decades of shear rate. In the example in question the comparability of two completely different measuring methods, capillary measurement with an extruder and oscillation measurement using a controlled stress rheometer, should be illustrated via measurements on an LLDPE. The dynamic viscosity of the capillary measurement and the complex viscosity of the oscillation measurement are shown in a diagram dependent on the shear rate (Fig. 1). The results of the capillary and oscillation measurements overlap in the transitional area of structural viscosity. A good correlation of the individual measuring sections can be arrived from this and the COX-MERZ rule can thus be confirmed.

**Example 2: The differentiation of compounds and masterbatches**

Mixer sensors are often used for the differentiation of compounds and masterbatches. In the example in question, a manufacturer was supplied two different titanium dioxides. When using one of these pigments, the production machine cut out due to an excessive power consumption. After examination in the mixer sensor, it was shown that the torque absorption of the one TiO₂ was much higher than that of the other supplier (Fig. 2). These type of measurements are often carried out in order to find quick solutions and e.g. to select the right supplier and as such they can save time and money consuming production tests.

![Fig. 1](image1.png)

![Fig. 2](image2.png)
Example 3: Die swell and viscosity

The viscosity behavior of melts influences the processing behavior to a great extent. For instance the viscosity determines whether the form is completely filled in the injection molding process and the elasticity determines the geometry of your finished product. Fig. 3 shows the results of two rubbers which exhibited similar flow characteristics i.e. viscosities during processing. They however resulted in completely different finished product cross sections. It can be recognized that the viscosity of both materials is reduced to virtually the same level with increasing load but the influence of the elasticity clearly increases.

![Die swell + Viscosity graph]

Fig. 3

Thermo Haake places its experience at your disposal in the form of laboratory and technical reports

We have listed a few examples below:
- Differentiating PVC Dry Blend Batches with an Extruder Sensor
- Flow and Cross-Linking Behavior of Cross-Linking Polyethylenes (XLPE)
- The Curing Behavior of Reaction Resin Compounds
- Characterizing Masterbatches Using the Screen Life Test Method
- Pigment Differentiation in Masterbatches
- Testing the Flow Characteristics of Glass Fiber Reinforced TPU
- Examining the Plasticizing and Degradation Behavior of PVC
- ......